Energy Technologies Area Lawrence Berkeley National Laboratory

Michigan Public Service Commission Integrated Resource Planning Stakeholder Group Meeting

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- Developed slides and presenting on on best practices in IRP development and the treatment of uncertainty and risk
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Today's Agenda

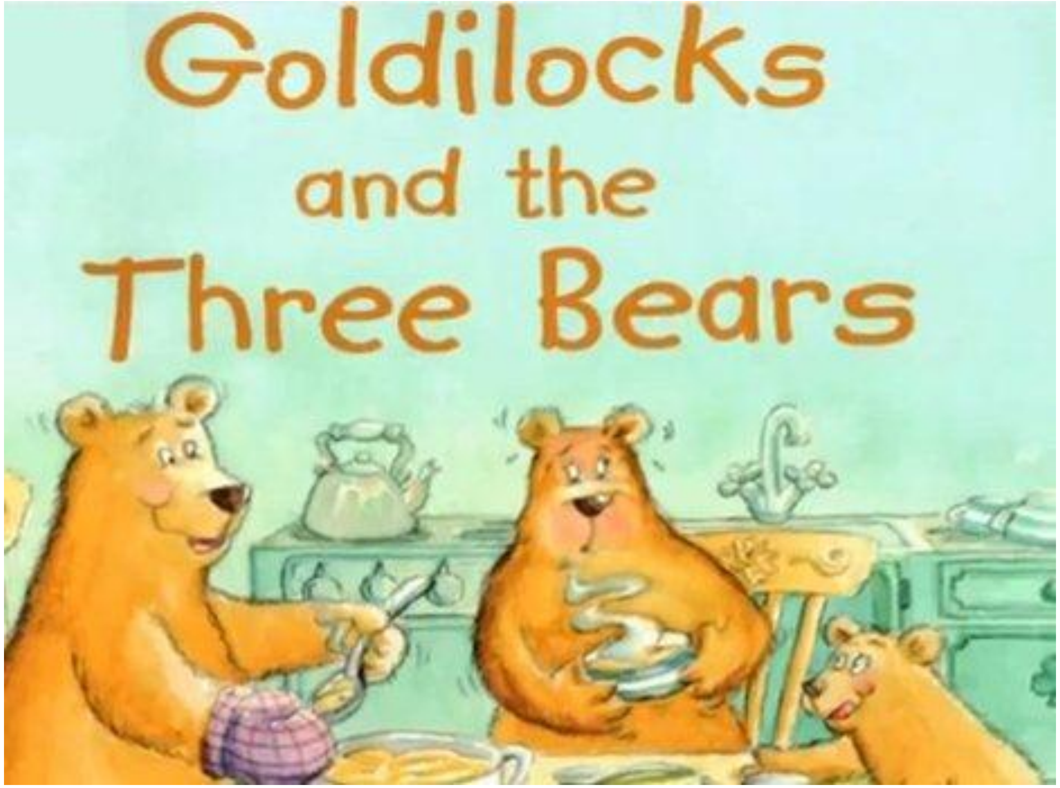
Time	Content
9:00 – 10:00 am	**Review of IRP content and development process** • **Focus on treatment of efficiency and demand response**
10:00 – 11:00 am	Time-varying value of energy efficiency research
11:00 - Noon	Uncertainty and Risk Analysis
Noon – 1:30 pm	Lunch break
1:30 – 3:30	Stakeholder engagement

Session 1 – Review of Prior Workshop

- What's an IRP?
  - What questions does it address?
  - What are its essential elements?
- What are "Best Practices" IRPs?
  - What are their critical inputs/assumptions?
  - What analysis is done to determine the preferred resource strategy?
  - What key information is provided?
- What are "best practices" for treating energy efficiency and demand response as resources
  - Achievable potential study assumptions
  - Calibration with load forecast
  - Modeling approaches
    - Direct competition with supply side resources
    - Load forecast adjustment

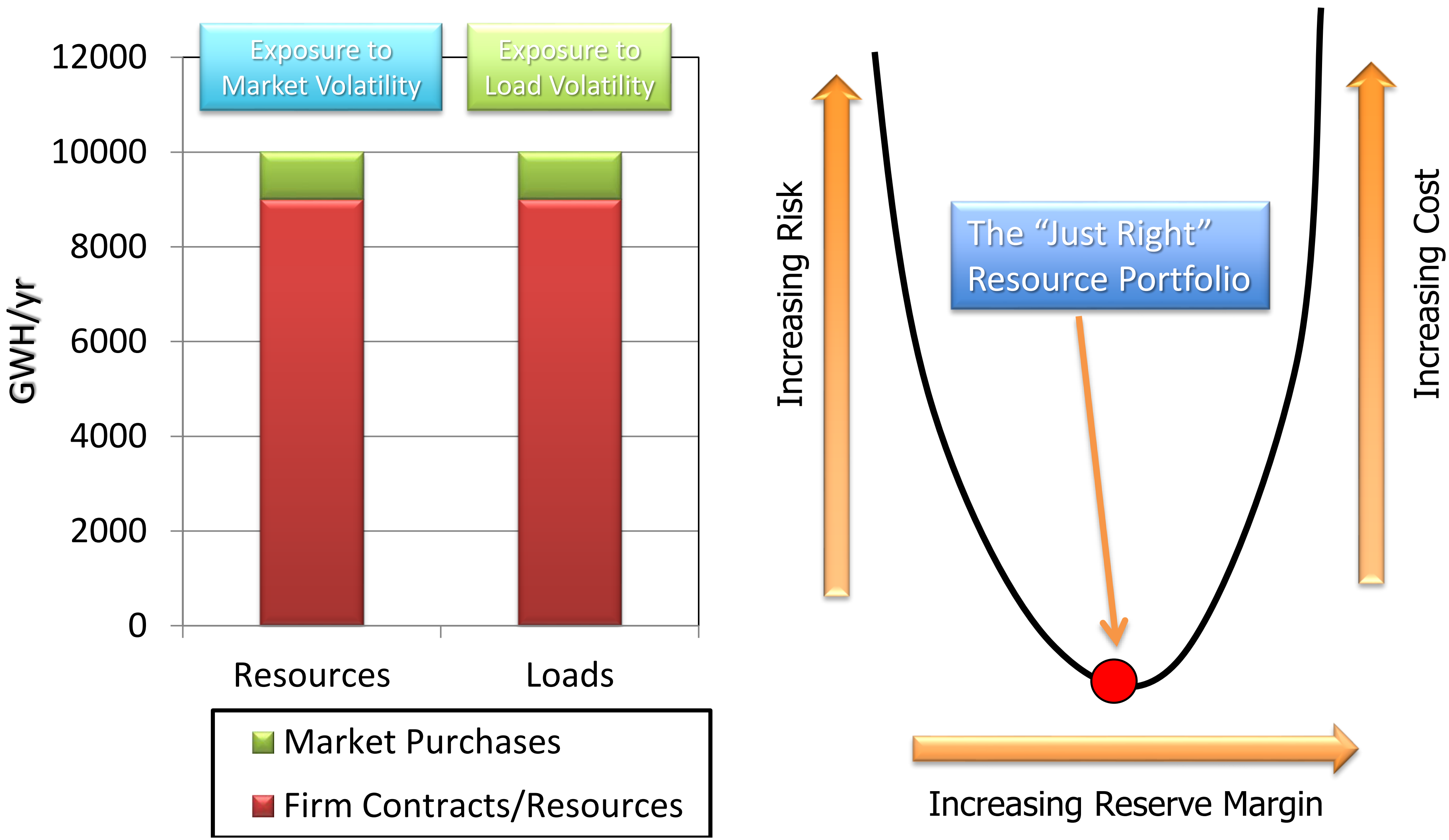
IRPs Are Intended to Address the Resource Planner's "Goldilocks Problem"

- Don't have too many resources
- Don't have too few resources
- Have "just the right amount" of resources*



*Resources include energy, capacity, flexibility and other ancillary services needed for system reliability.

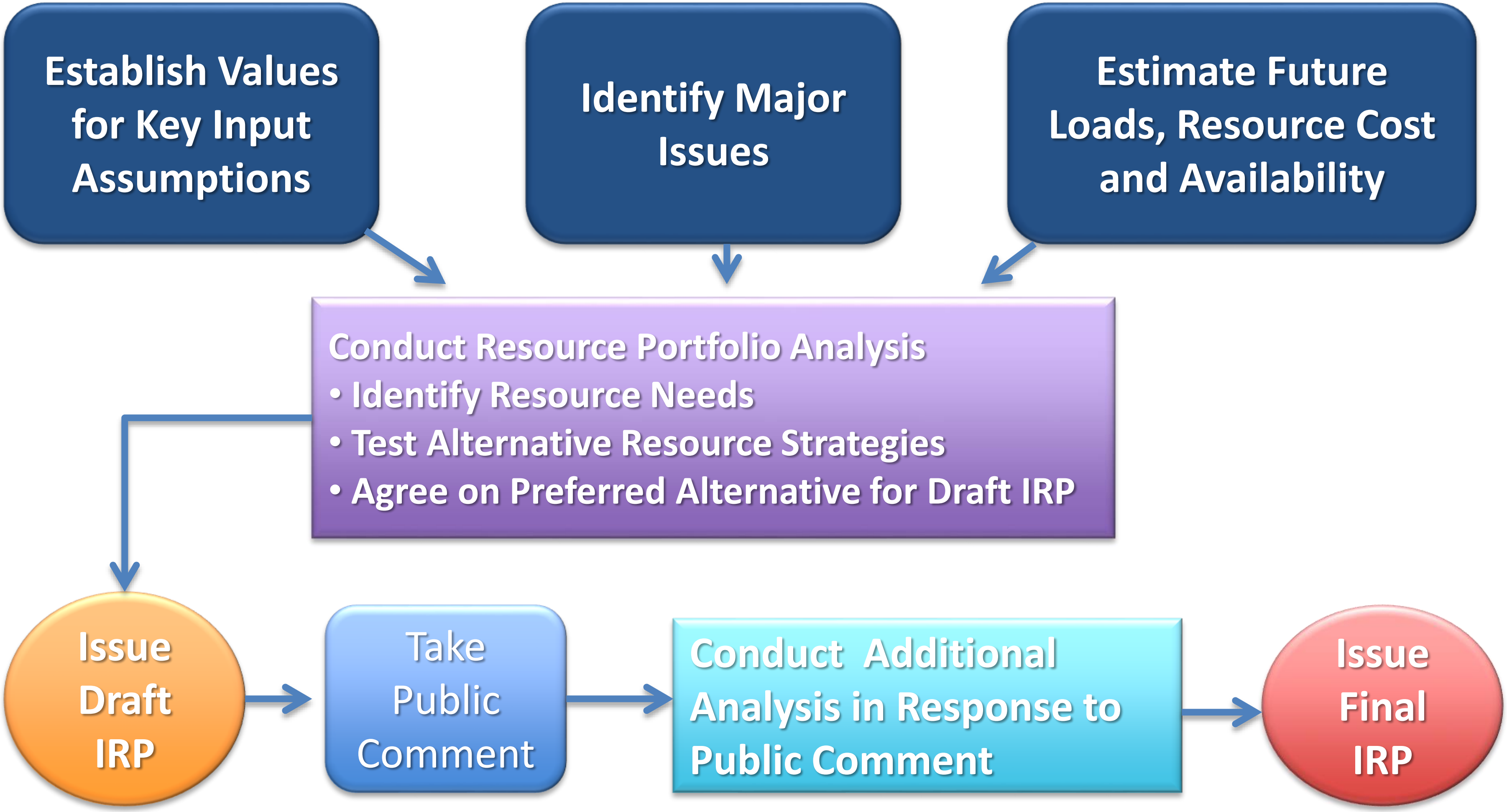
Why "Just Right" Matters:
As A Utility's Resource Mix Changes So Does Its Cost and Risk



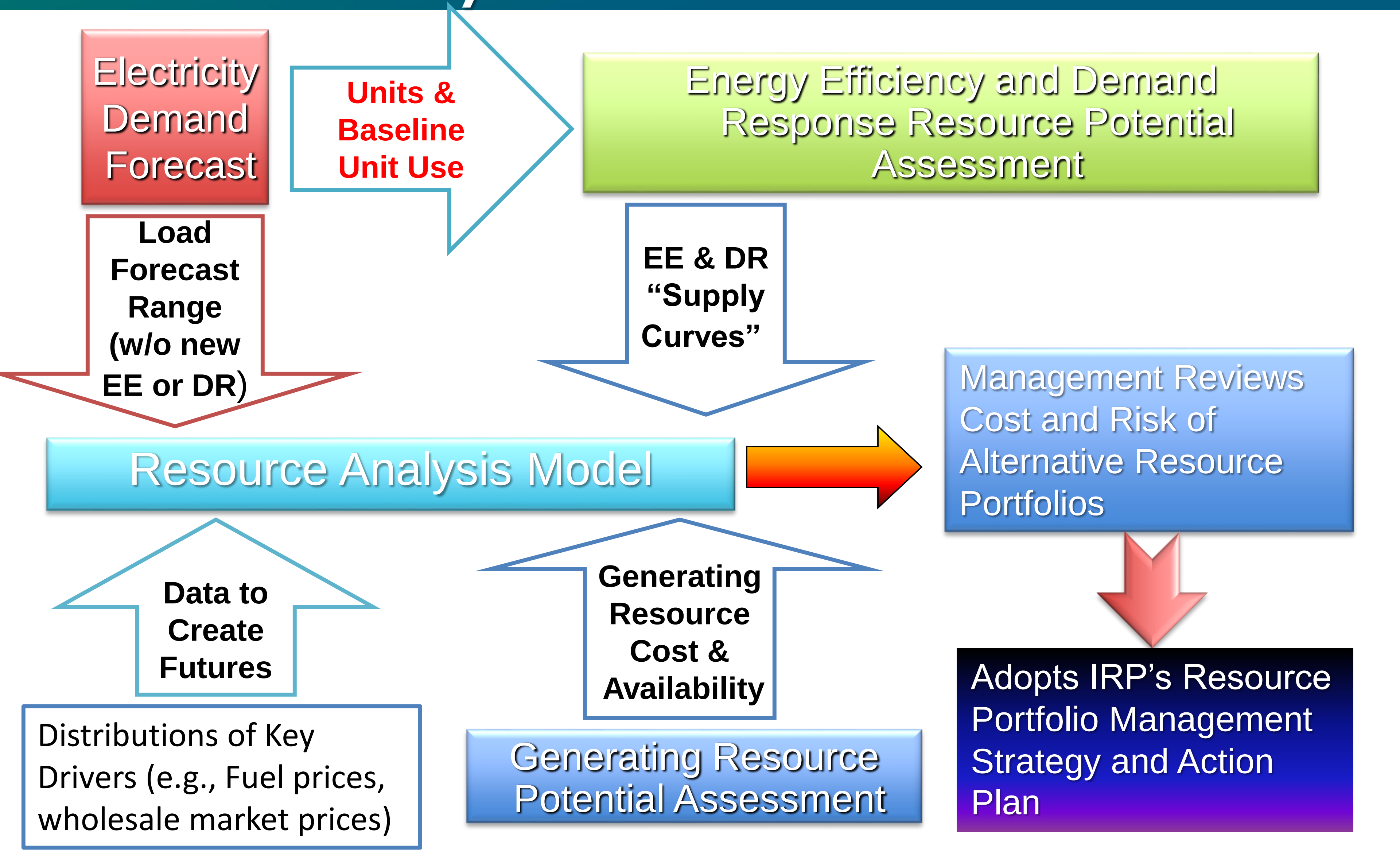
IRPs Attempt to Find the "Just Right" Resource Mix by Answering Five Simple Questions

1. *When Will We Need Resources?*
2. *How Much Will We Need?*
3. *What Should We Build/Buy?*
4. *How Much Will It Cost?*
5. *What's the Risk?*

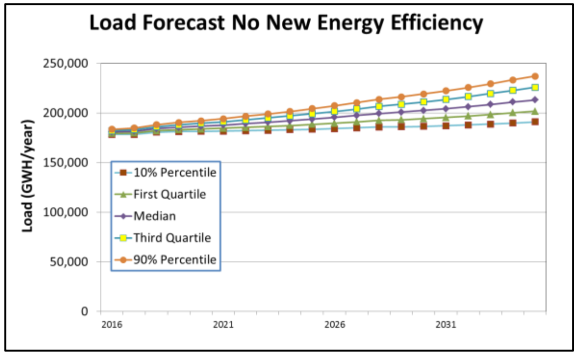
Overview of Best Practice IRP Development Process

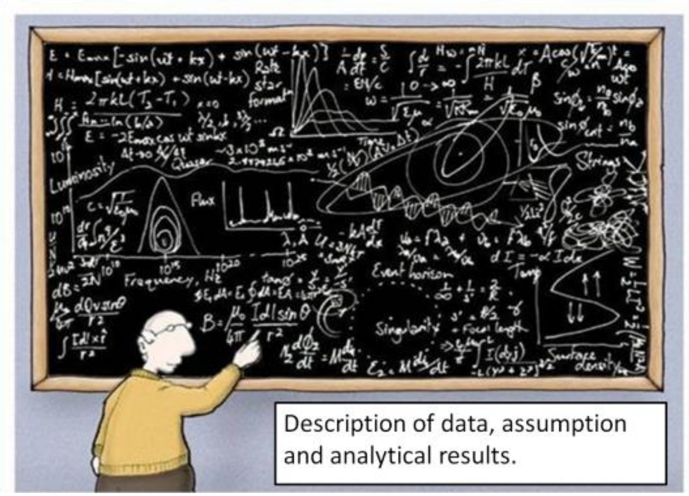


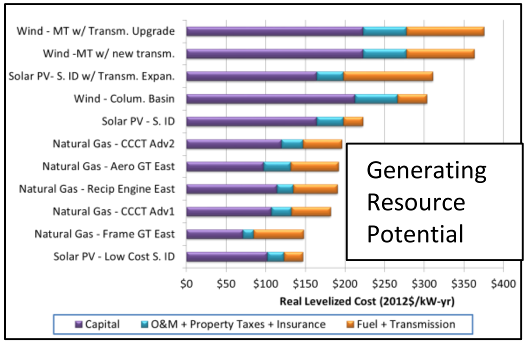
Best Practice IRP Development Analytical Process Flow



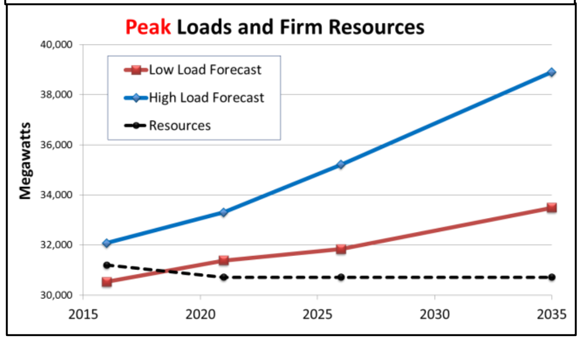
Key Components of Best Practice IRPs

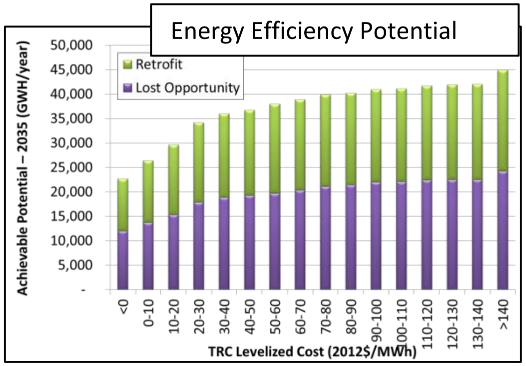






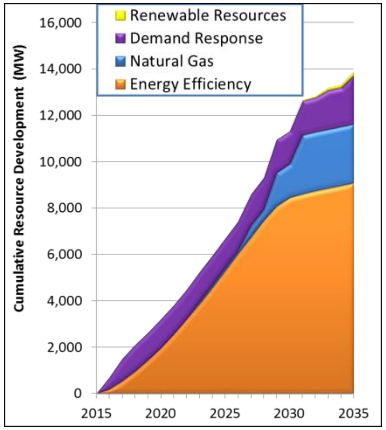
Resource Needs/Adequacy Assessment



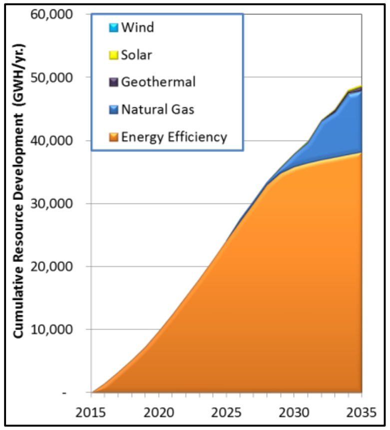


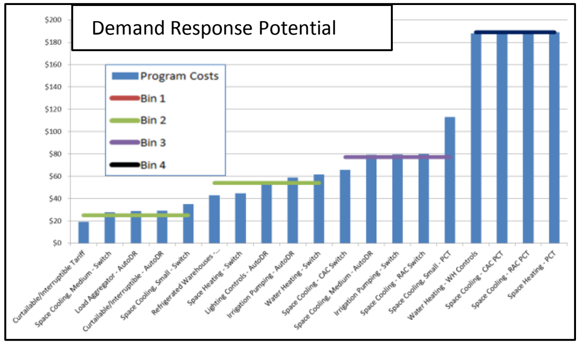
Resource Portfolio/ Strategy

Capacity Resources



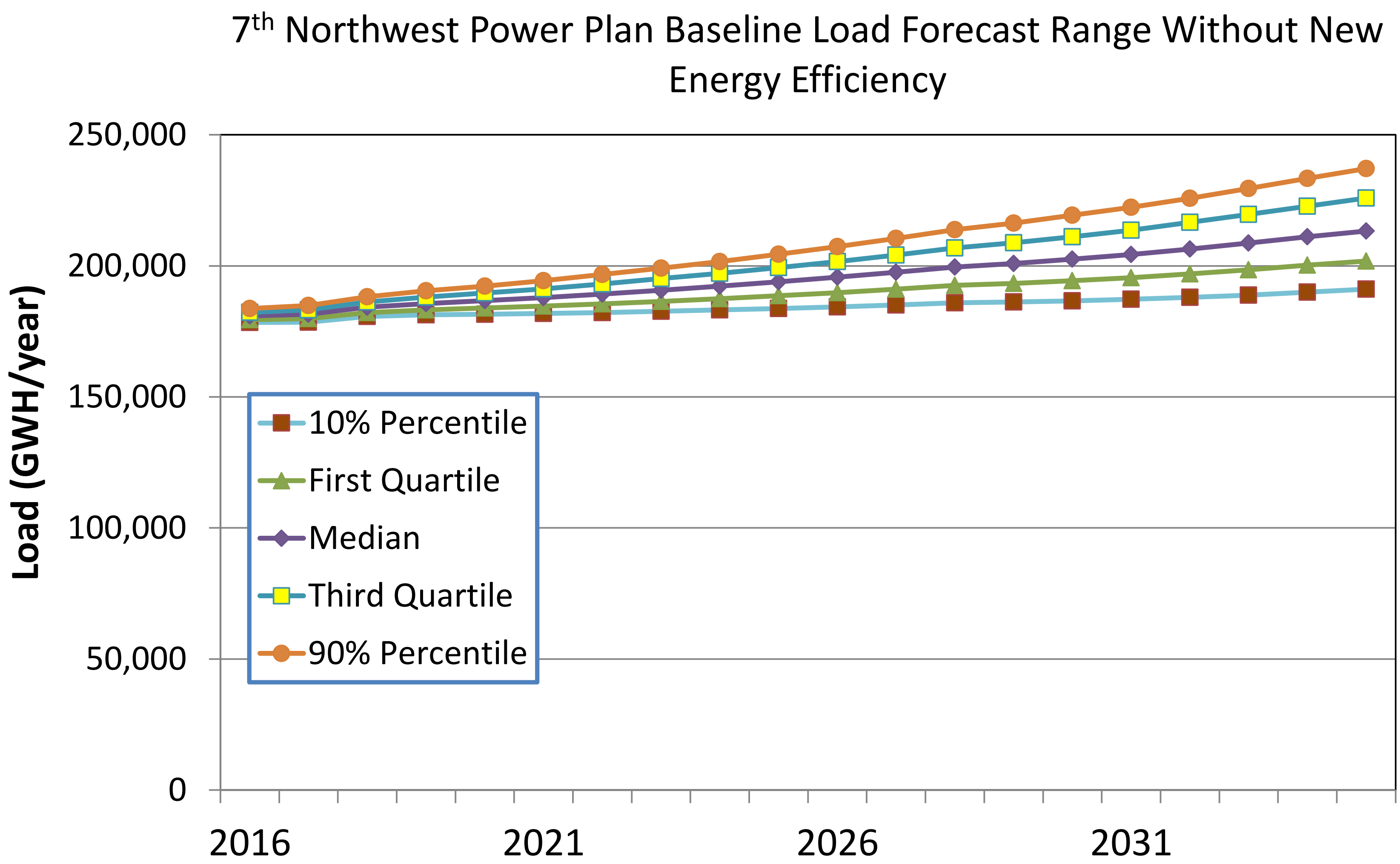
Energy Resources



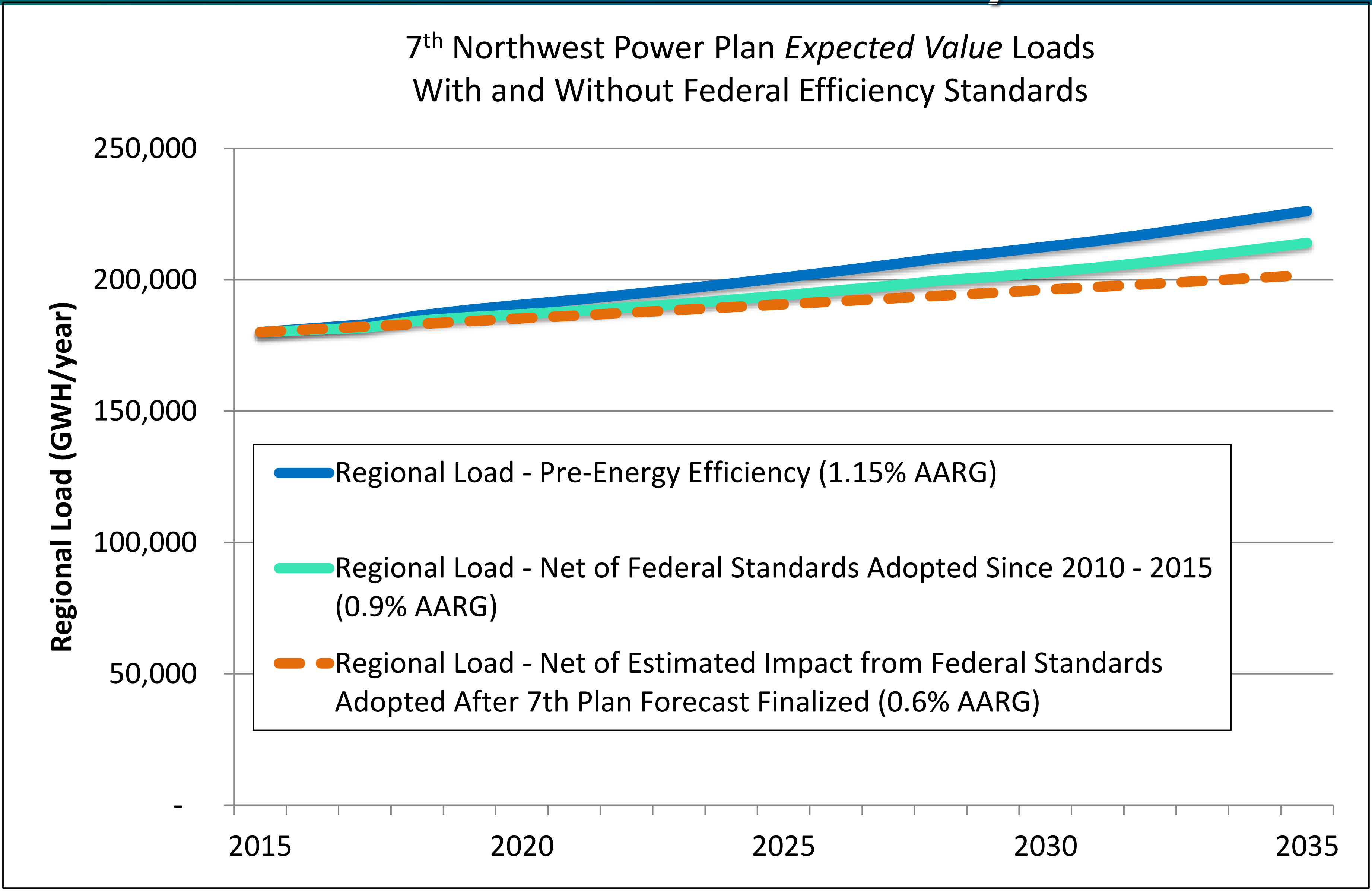


Action Plan

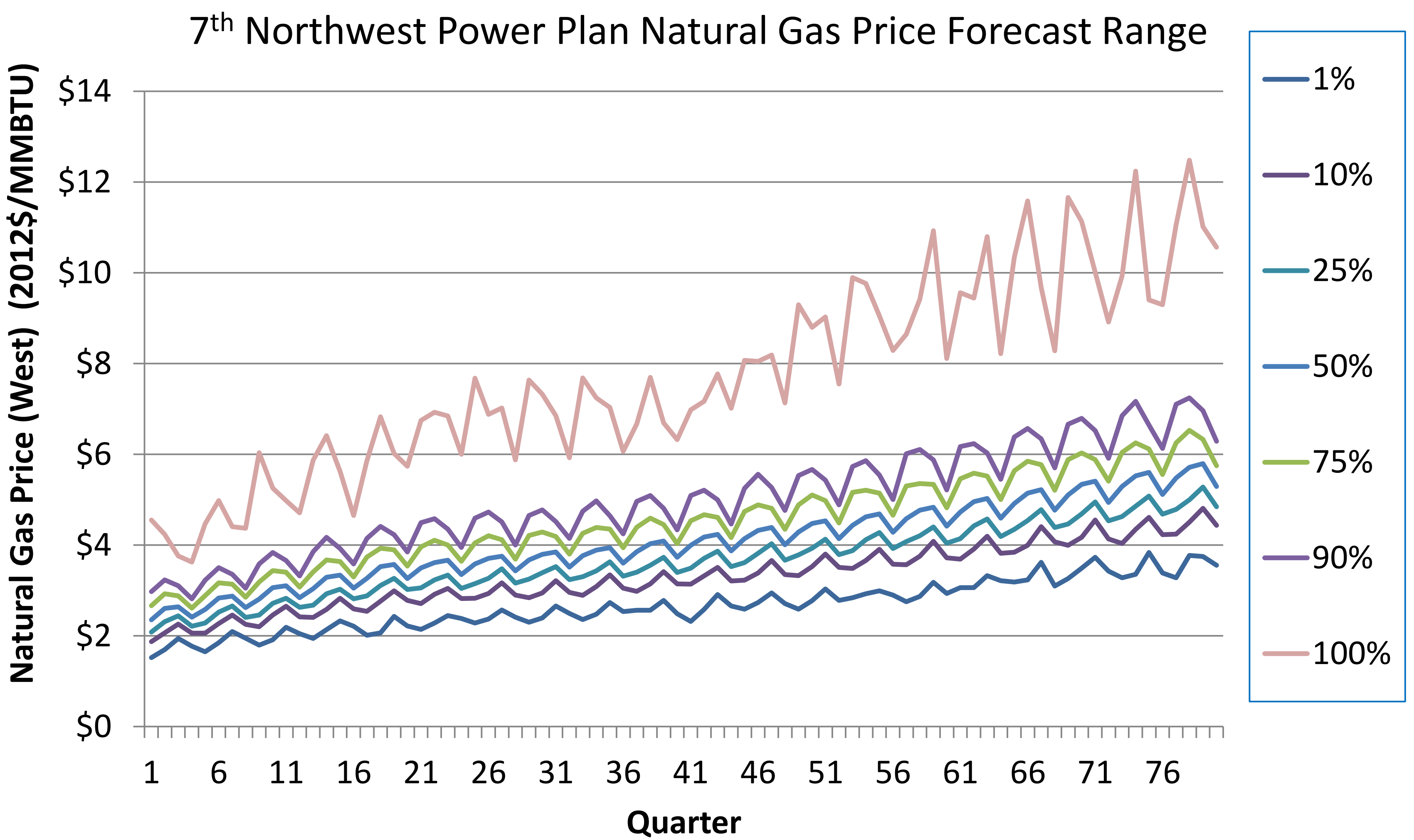
Best Practice Baseline Load Forecast Provided as a Range Without Additional Energy Efficiency



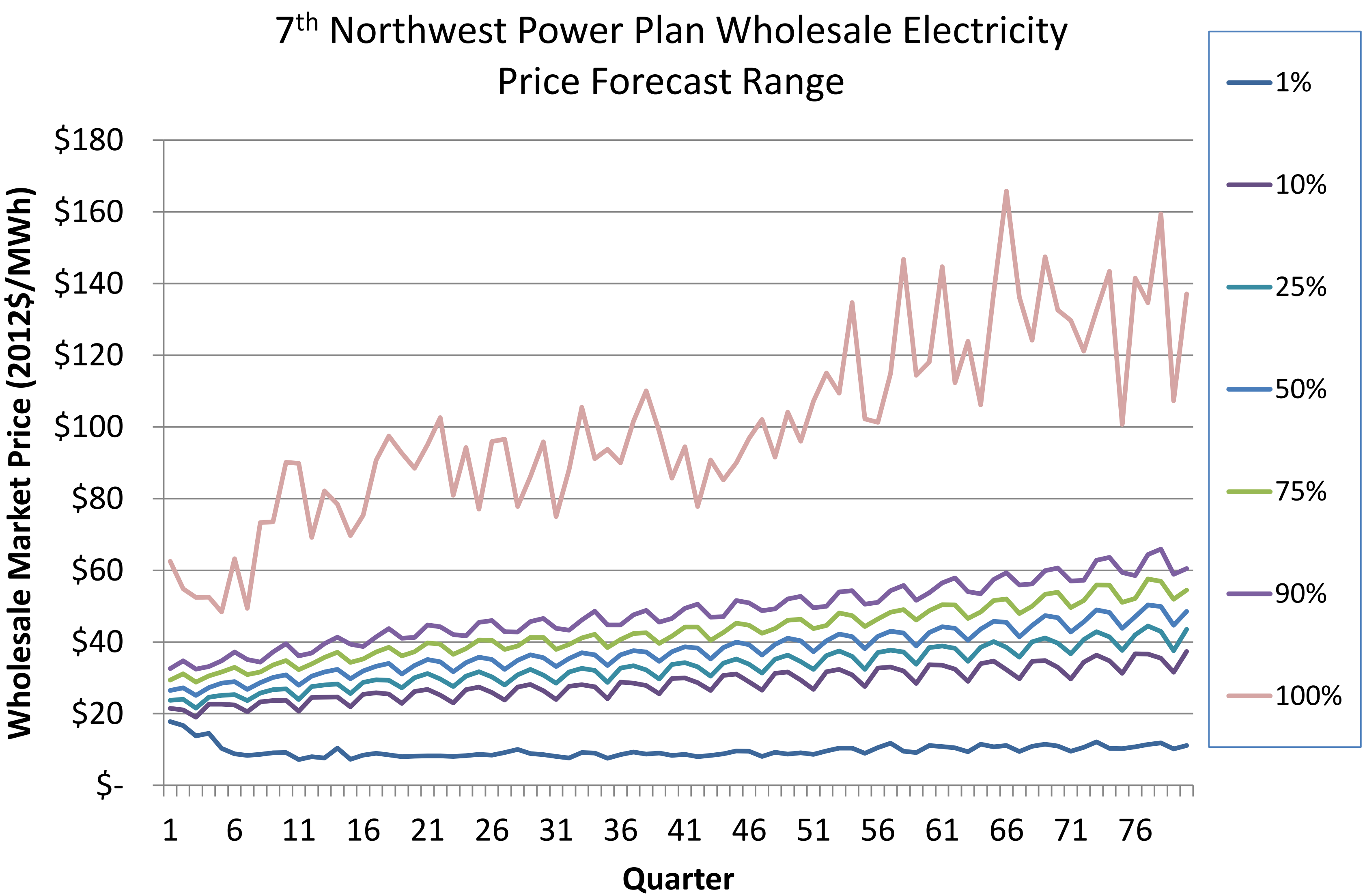
Best Practice Load Forecast Reflect Impacts of Known Codes and Federal Efficiency Standards



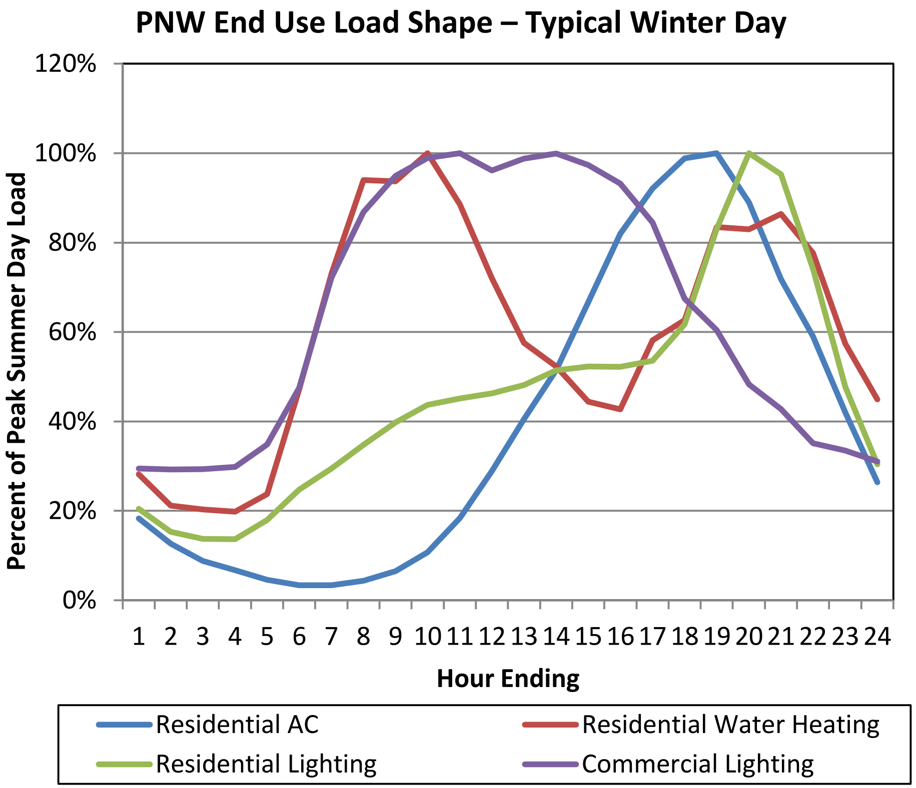
Best Practice Forecast of Natural Gas (and other fuel) Prices Cover A Range of Future Conditions

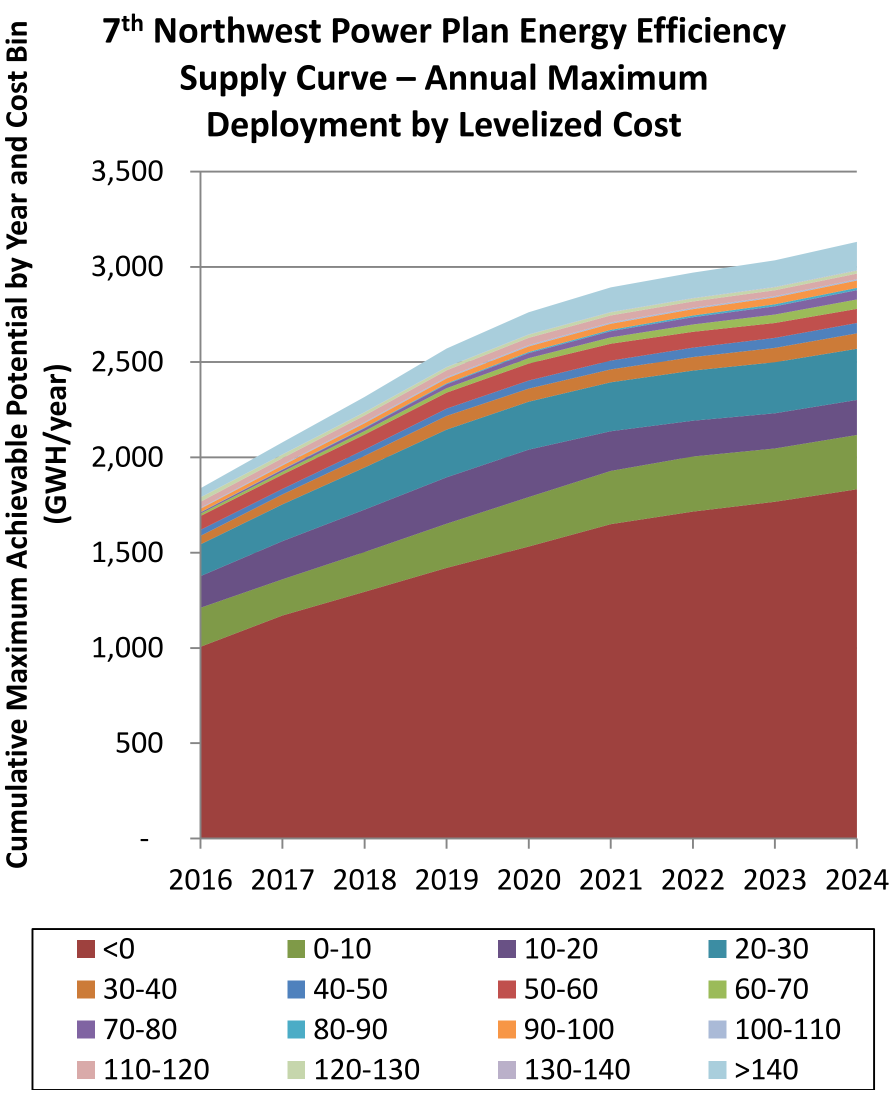


Best Practices Forecast of Wholesale Electricity Prices Are Provided As A Range



Best Practice Energy Efficiency Resource Assessments Include Load Shape and *Achievable* Potential Deployment Limits





Input Assumptions Regarding *Annual* and *Cumulative Achievability*

Maximum Achievability Over Planning Period

- Reflect *gross* savings from all mechanism (e.g., programs, codes, standards, market transformation, etc.).
  - Free-ridership (i.e., the share of the population that is already adopting measure) should be captured in load forecast model
- Treating EE is a resource means that acquisition payments to consumers up to the value of avoided utility system cost can be legitimately (i.e. are cost-effective) assumed so that economic barriers to participation are less of a constraint
- Limits to achievability should reflect continuous program operation across the entire planning period (10 - 20 years)
- Limits on lost opportunity resource achievability should reflect potential adoption of codes and standards as well as other market transformation activities

Best Practice Input Assumptions
How Much is Energy Efficiency Is Achievable?

- How much of the identified energy efficiency potential:
  - Can we expect to 'achieve'
  - Over what time frame?

Evidence strongly suggest that:

- At least 85 percent of retrofit economic potential is achievable over 20 year time frame
- At least 65 percent of "lost opportunity" economic potential is achievable over 20 year time frame
- Annual savings equivalent to at least 2.5 percent of retail sales is achievable

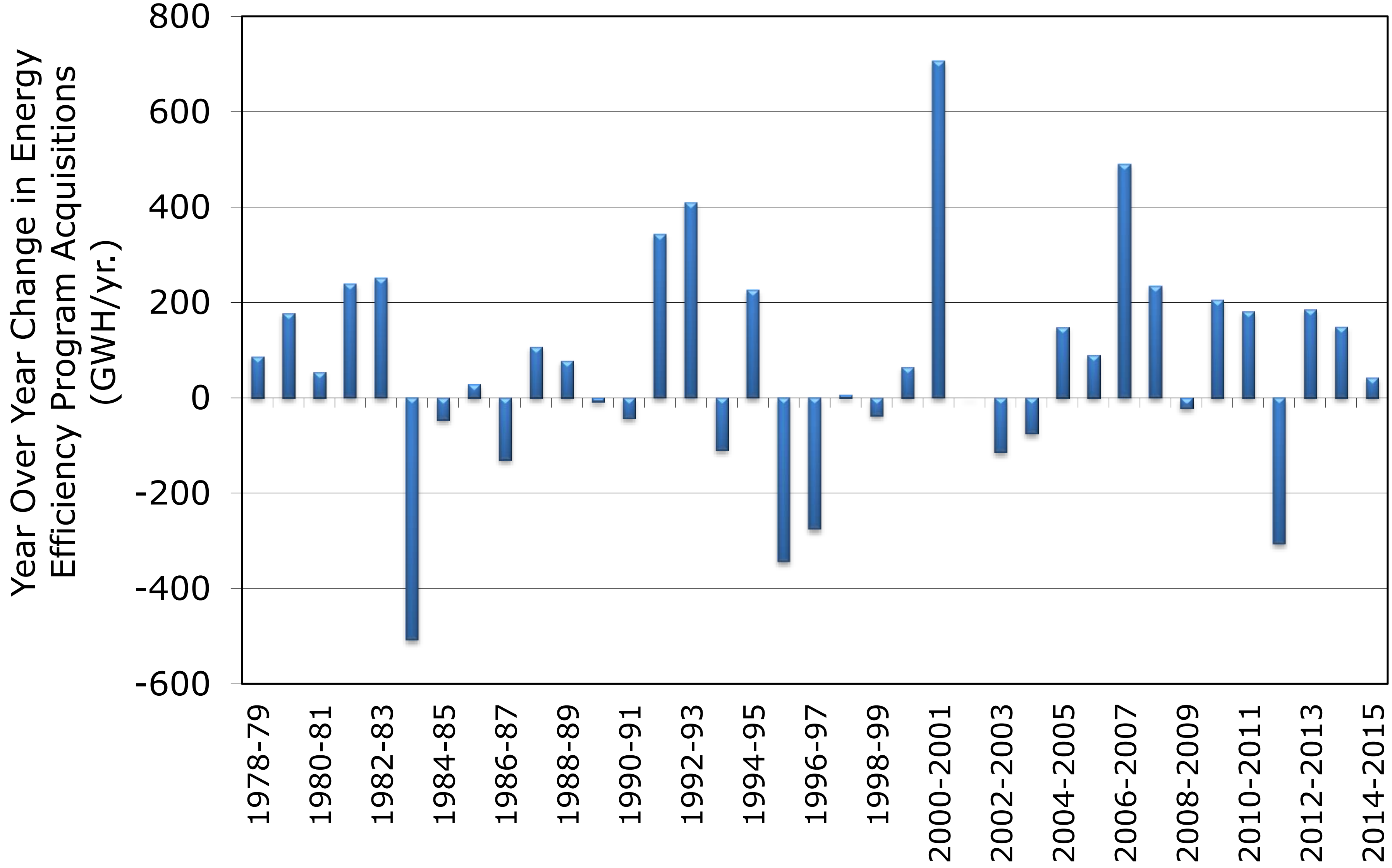
Why the 1983 "Achievable Potential" Forecast Was Important

- In 1983 *lead times* for construction of new generation (coal & nuclear) were 12-15 years
  - Even if successful, "options" would only defer construction lead time by 5-7 years
- Average resource size ~ 1000 MW
- Therefore, if energy efficiency resources were to offset the construction of new generation "achievable savings" had to be reliably forecast for 12-15 years into the future

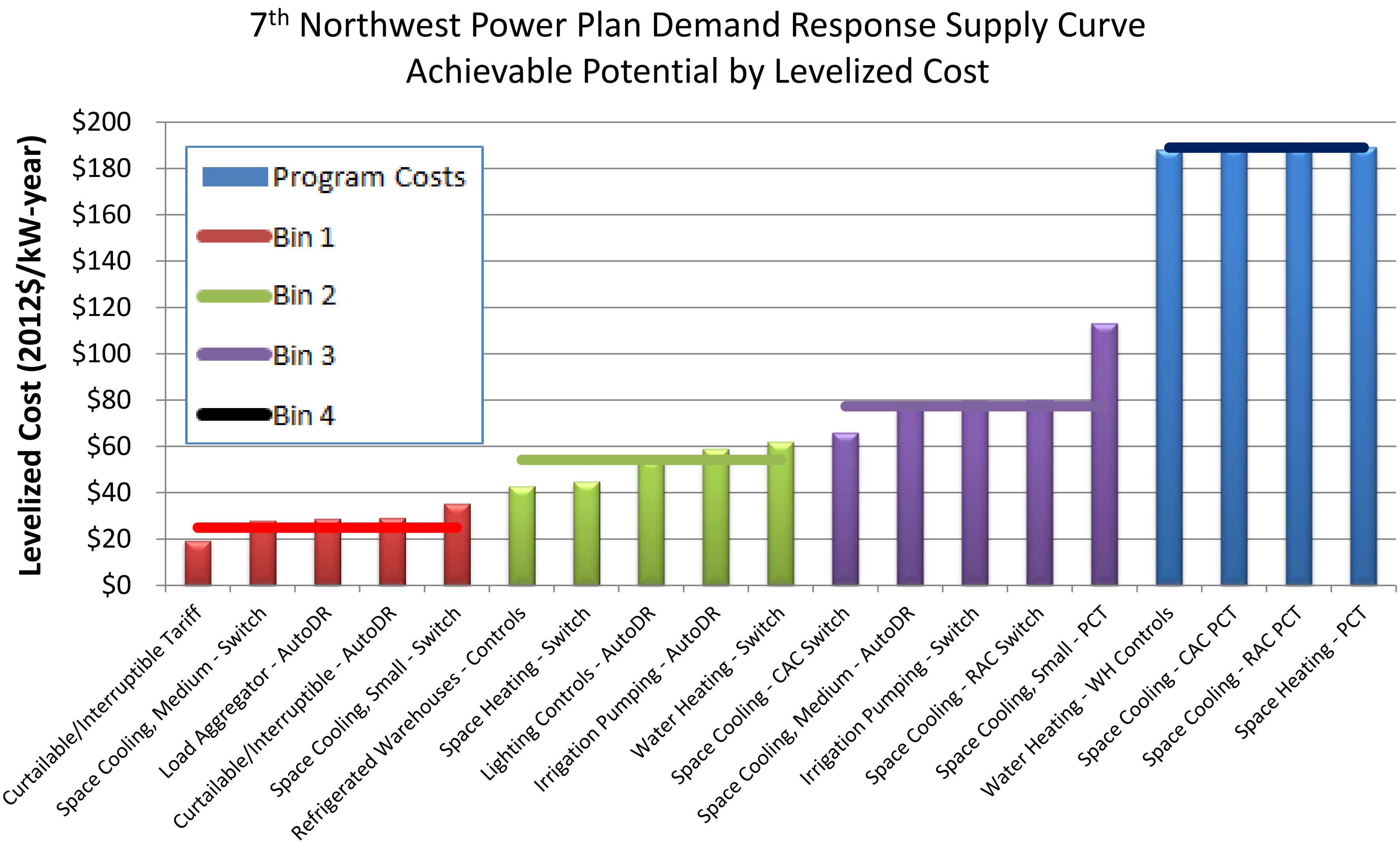
Why It's Less Important Today

- Lead time for new generating resources is 2-5 years
- Average resource size ~ 250 – 350 MW
- Ability to expedite (or delay) construction now greater
- Critical assumption is now "near-term" ramp rate, rather than long term "maximum achievable"
  - Low probability that "unknown" new EE technology can achieve significant market scale
  - Potential studies can (and should) be regularly updated to reflect new information and technologies

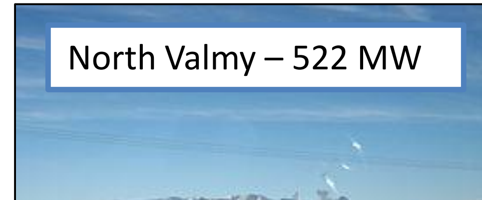
Ramp Rate Constraints On Year-over-Year Change in Energy Efficiency Acquisitions Are Generally Not Limiting Over A Wide Range

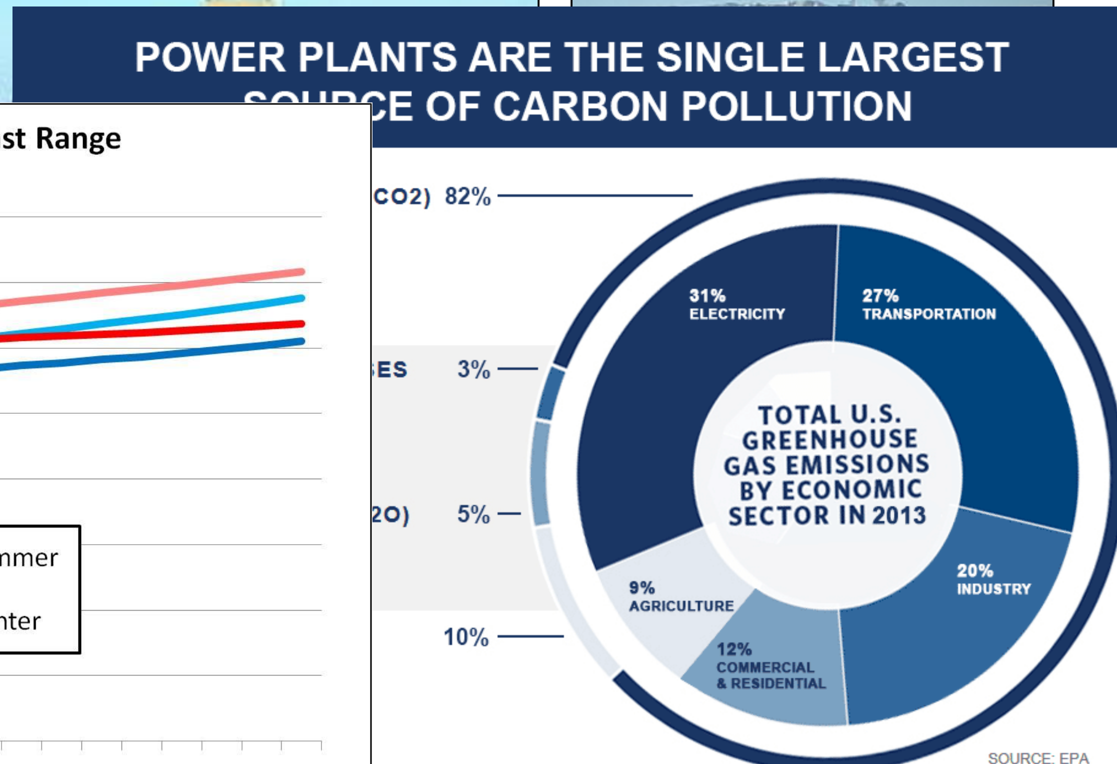


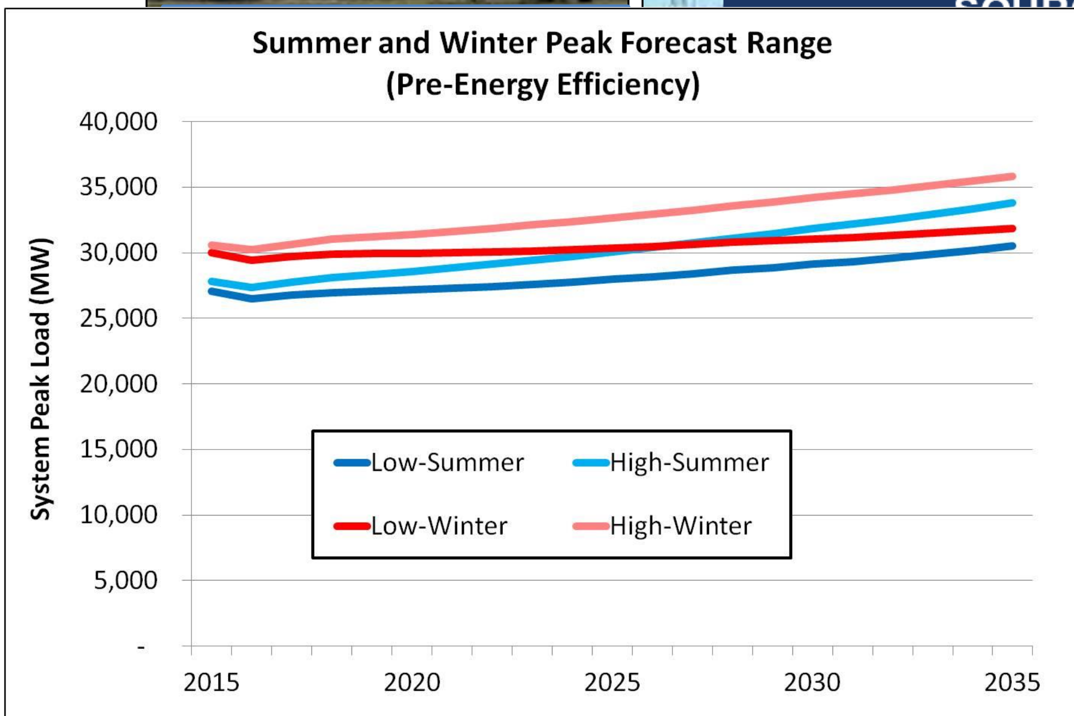
Best Practice Demand Response Resource Assessment Include Demand Response Achievable Potential and Deployment Limits



Best Practice IRPs Include Descriptions of Major Issues Potentially Impacting Resource Planning Environment







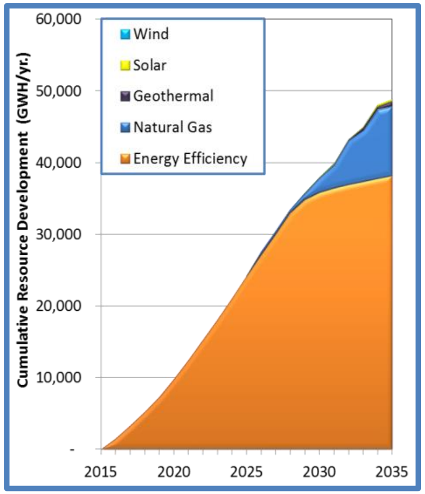
Implications of and options for addressing EPA's Clean Power Plan

How to best meet regional need for capacity (i.e., peaking) resources

Best Practice IRPs "Stress Test" Alternative Resource Portfolios Over A Range of Future Conditions
They Do Not Assume Perfect Foresight

Resource Strategies – actions and policies over which the decision maker *has control* that will affect the outcome of decisions

Futures – circumstances over which the decision maker *has no control* that will affect the outcome of decisions



- Load Uncertainty
- Resource Uncertainty
  - Output
  - Cost
  - Construction Lead Times
  - Technology Change
- Wholesale Electricity Market Price Uncertainty

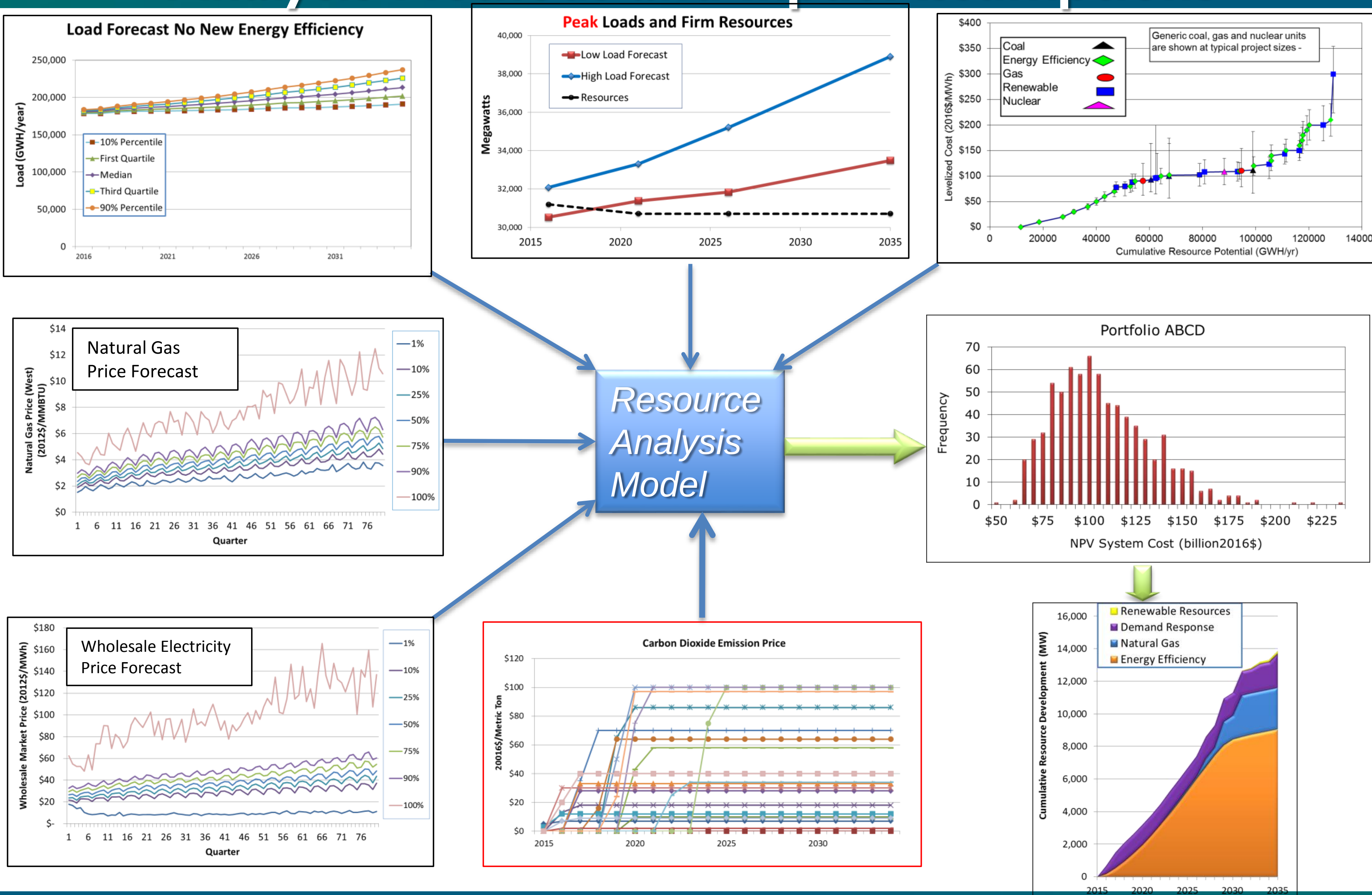
Scenarios – Combinations of *Resource Strategies* and *Futures* used to "stress test" how well what we control performs in a world we don't control

Best Practice IRPs Include Descriptions of the Scenarios Tested

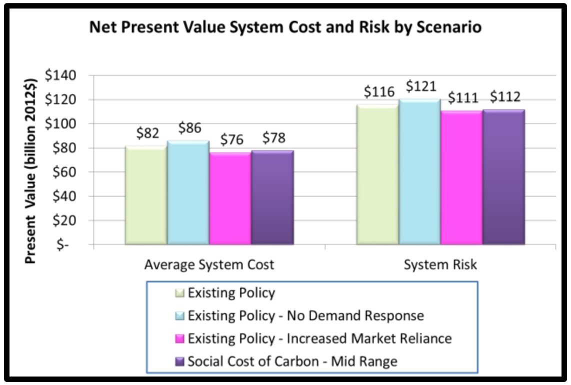
Example: Over Two Dozen Scenarios Were Tested As Part of the Development of the Council's Seventh Power Plan

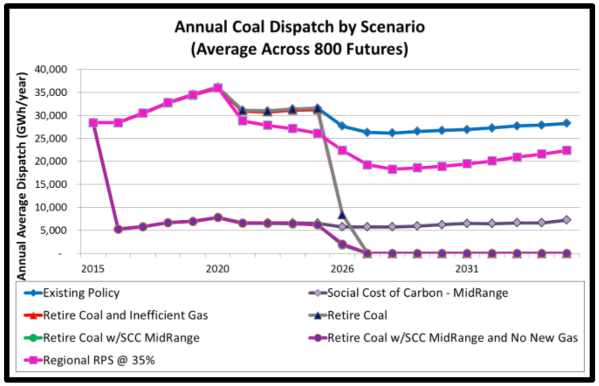
- Existing Policy
- Social Cost of Carbon
- Retire Coal
- Retire Coal and Inefficient Gas
- Retire Coal & Impose Social Cost of Carbon
- Retire Coal & Impose Social Cost of Carbon & No New Gas
- Regional RPS @ 35%
- No Demand Response
- Increase Market Reliance
- Limit Energy Efficiency Acquisitions to Market Price

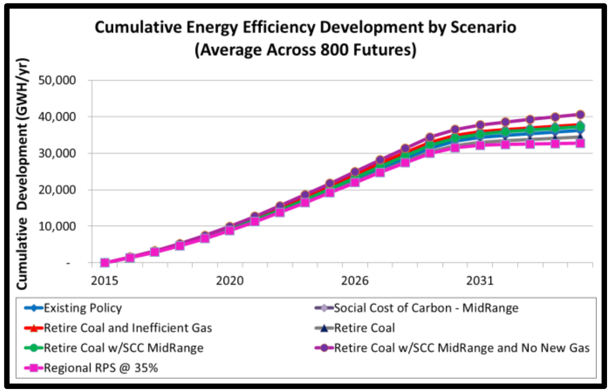
Best Practice IRPs Include Description of Resource Analysis Methods and Input Assumptions

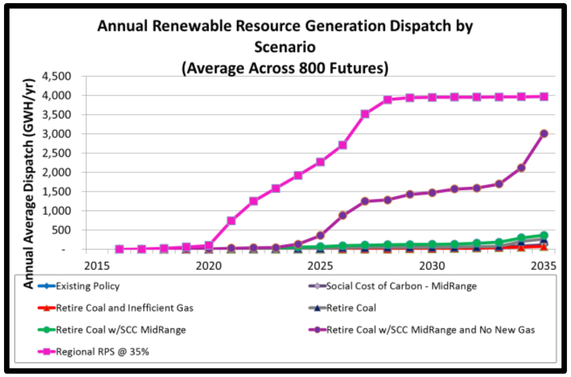


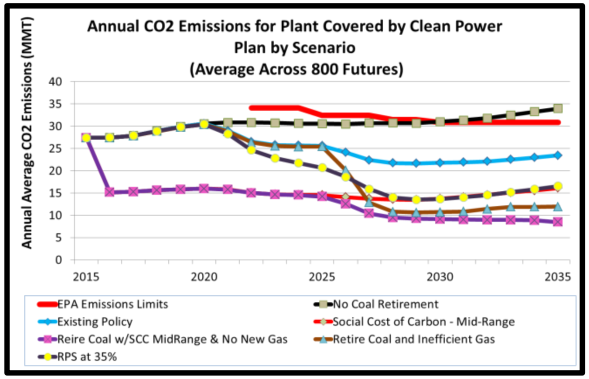
Best Practice IRPs Discuss Major Analytical Findings
Example – 7th Northwest Power and Conservation Plan

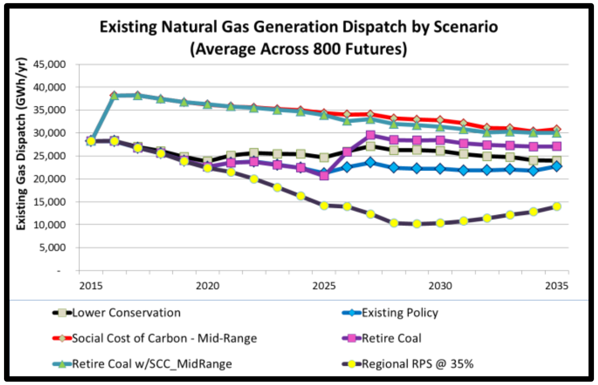


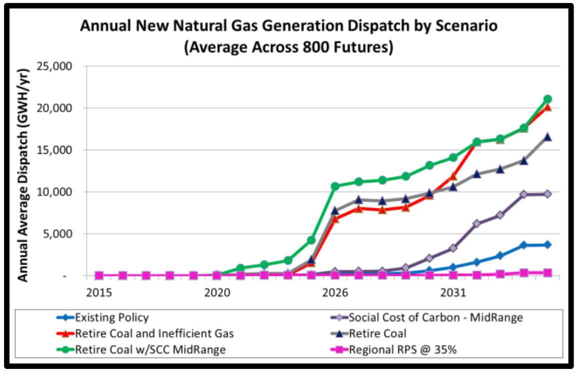


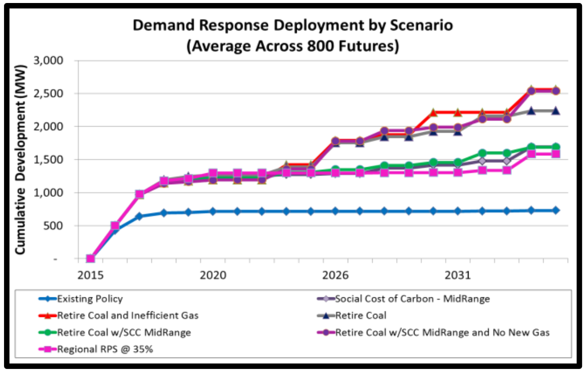


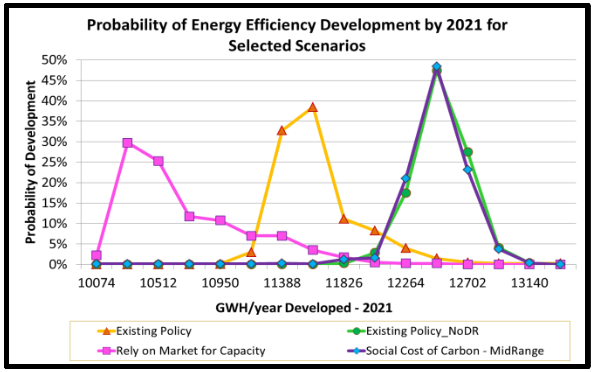






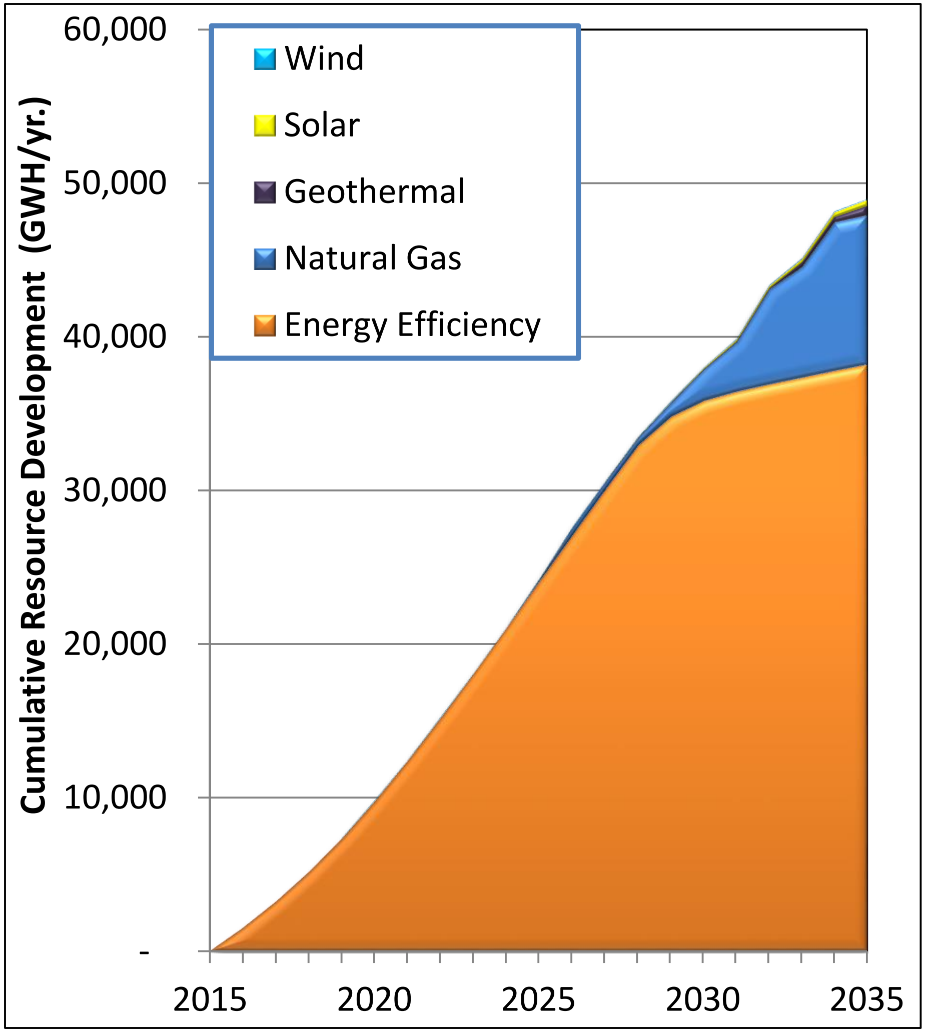


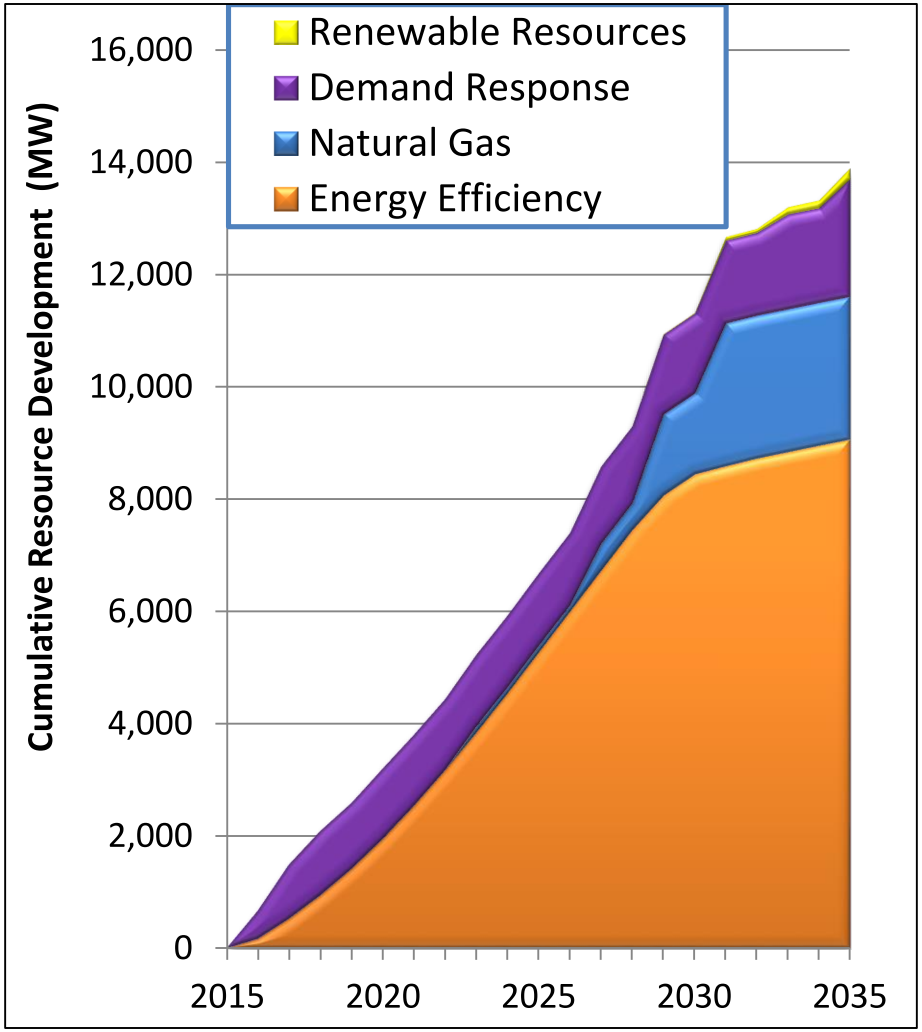




Best Practice IRPs Set Forth A Preferred Resource Strategy for Meeting Forecast Energy and Capacity Needs Over Their Entire Planning Period

7th Northwest Power Plan Expected Value Development Schedule by Resource Type for Energy and Capacity





Best Practice IRPs Include An Action Plan

- Preferred Resource development/management actions
  - EE & DR goals
  - Generation, including ancillary services/reserves
  - Transmission and Distribution
  - Risk management
- Non-resource development actions
  - Analytical capability enhancement
  - Data development
  - Research on emerging technologies

Models Used in IRP Development

- Load Forecasting
  - Econometric
  - End Use Econometric
  - Statistically Adjusted Engineering
- Capacity/Resource Expansion Models –
  - These models simulate generation and transmission capacity investment, given assumptions about future electricity demand, fuel prices, technology cost and performance, and policy and regulation
  - Examples - Aurora, System Optimizer, Strategist, PLEXOS, the Council's Regional Portfolio Model, and NREL's Resource Planning Model
  - Key differences between models
    - Treatment of uncertainty (i.e., does the model optimize for a single future or scenario or does it optimize across a range of future conditions)
    - Time resolution (i.e., many do not have chronological unit commitment (i.e., every hour of the year chronologically) and some use aggregate (model) plants for dispatch). This can limit there ability to model DR.
    - Transmission and power flow are a stylized representation (pipe flow or DC)

Role of Capacity Expansion/Resource Analysis Models

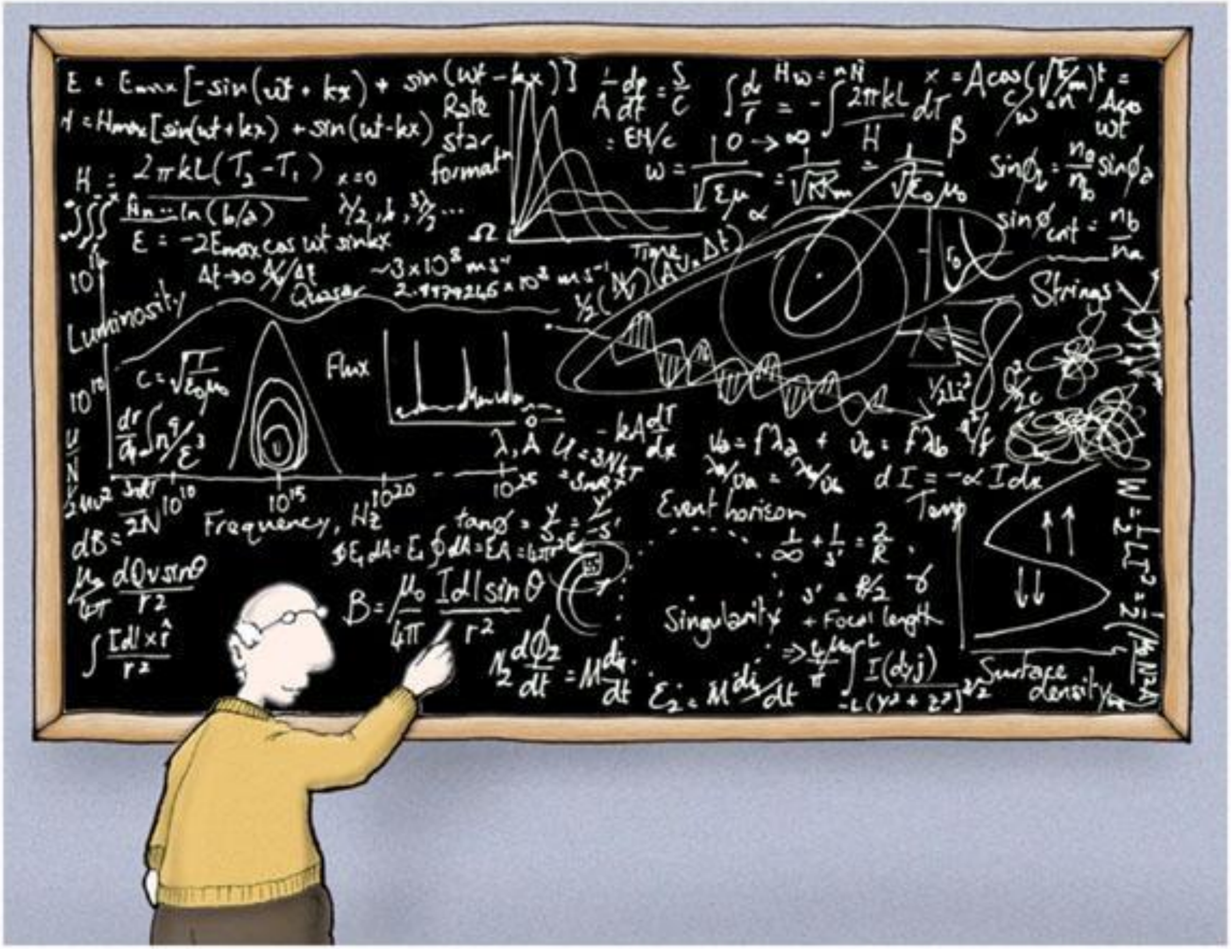
What They Do Do

- Test alternative resource mixes and development timing (aka, *Resource Strategies*) against a range of future conditions (e.g., load growth, natural gas prices, emissions costs/limits, etc.)
- Identify the "least cost" *Resource Strategy* <u>and may or may not</u> account for "risk"

What They Don't Do

- Determine what is an acceptable level of "cost"
- Determine what is an acceptable level of "risk"
- Decide which *Resource Strategy* is "Preferred"

Determining The Amount and Pace of EE and DR Development in an IRP



In Many IRPs the Amount of EE Determined in Through Six Step Process

- *Step 1* - Estimate *Technical Potential* on a *per application* basis (i.e. savings per unit)

- Step 2 – Estimate *Economic Potential* on a *per application* basis (i.e., levelized cost per unit) based on "avoided cost" of "proxy" resource or capacity expansion model marginal resource analysis

- Step 3 - Estimate *number of applicable units* (account for physical limits, retirements, new construction, etc.)

- Step 4 – Estimate *Economic Potential* for *all applicab*le units

- Step 5 – Estimate *Economically Achievable* Potential for *all realistically achievable* units

- Step 6 - Reduce the load forecast provided to the capacity expansion model by the amount of *economically achievable* savings resulting from Step 5 before that model is used to "optimize" the supply side resources.

In Best Practice IRPs the Amount of EE is Determined in a Five Step Process – and the Order is Different

- *Step 1* - Estimate *Technical Potential* on a *per application* basis (i.e. savings per unit)

- Step 2 - Estimate *number of applicable units* (account for physical limits, retirements, new construction, etc.)

- Step 3 – Estimate *Technical Potential* for *all applicab*le units

- Step 4 – Estimate *Achievable* Potential for *all realistically achievable* units

- Step 5 – Estimate *Economic Potential* for *all realistically achievable* units by competing EE against supply side resources in capacity expansion modeling*

*Where EERS requirements exist (as in Michigan), they are typically modeled as "must build" resources and only additional increments above the minimum EERS "compete" against generating resources in capacity expansion modeling.

Establishing the Amount and Timing of EE and DR Development Through Direct Completion

- Allows *optimization* across all resources based on their cost, load shape/load following characteristics and risk
- Requires capacity expansion models that are capable of accepting “acquisition decision and development rules” for EE and DR
- Is less useful when deterministic (versus probabilistic) capacity expansion models are used
  - Because there’s no uncertainty regarding the answers to the planner’s five simple questions

Important Concepts/Principles for Both Methods Interaction with Load Forecast

- Internal consistency between load forecast and energy efficiency assessment is necessary to avoid potential for *over* or *under* estimating remaining EE potential
  - Baseline use/efficiency assumptions should be equivalent
  - "Units" (e.g. houses, commercial floor space, appliance counts) should be identical
  - Internal consistency is most readily achieved when end-use and SAE load forecasting models are used
  - When econometric load forecasting models are used "calibration" between load forecast and EE potential assessments is typically done at the sector (i.e., residential, commercial) level.
    - This is typically done by translating measure level EE savings in kWh derived from the potential assessment to percent improvements off a baseline and reducing the load forecast by these percentages.

Questions?

Resources

- Northwest Power and Conservation Council's Seventh Power Plan

  (https://www.nwcouncil.org/energy/powerplan/7/plan)
- Using Integrated Resource Planning to Encourage Investment on Cost-Effective Energy

  (https://www4.eere.energy.gov/seeaction/publication/using-integrated-resource-planning-encourage-investment-cost-effective-energy-efficiency)
- Best Practices in Electric Utility Integrated Resource Planning - Examples of State Regulations and Recent Utility Plans (http://www.raponline.org/wp-content/uploads/2016/05/rapsynapse-wilsonbiewald-bestpracticesinirp-2013-jun-21.pdf)
- Practicing Risk-Aware Electricity Regulation: What Every State Regulator Needs to Know

  (http://www.raponline.org/knowledge-center/practicing-risk-aware-electricity-regulation-what-every-state-regulator-needs-to-know/?sf_action=get_results&_sft_topic=energy-resource-planning+integrated-resource-planning)
- LBNL – Resources on Integrated Resource Planning (https://emp.lbl.gov/projects/utility-resource-planning)

Resources

- Berkeley Lab [Resource Planning Practices and Trends]webpage, with links to over 20 years of research on resource planning
- Indiana Utility Regulatory Commission Electricity Division's IRP Contemporary Issues Technical Conferences. Current and past year's agendas and presentations here: http://www.in.gov/iurc/2340.htm
- Kahrl et al. (2016). The future of electricity resource planning. Available at: https://emp.lbl.gov/publications/future-electricity-resource-planning
- Satchwell et al. (2013). Analytical frameworks to incorporate demand response in long-term resource planning. Available at: https://emp.lbl.gov/publications/analytical-frameworks-incorporate
- Satchwell et al. (2013). Incorporating demand response into western interconnection transmission planning. Available at: https://emp.lbl.gov/publications/incorporating-demand-response-western
- Synapse (2013). Best practices in electric utility integrated resource planning. Available at: http://www.synapse-energy.com/project/best-practices-electric-utility-integrated-resource-planning

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Session 1: Review Back-up Slides

Special Considerations for Direct Competition Method – Interaction with Load Forecast and Resource Cost

When “direct competition” method is used to determine EE and DR development

- All potential EE and DR improvements are treated as resource options that compete against generating resources in supply expansion model and characterization includes both energy and capacity impacts
- Load forecast are not decremented with assumed level of EE and DR*
- Baseline load forecast used in capacity expansion/resource optimization model assume “frozen efficiency” (i.e., no price responsive improvements occur) only efficiency improvements from stock turnover and known codes and standards
- EE and DR costs should reflect all utility system impacts not accounted for in capacity expansion resource optimization process
  - Example – Capacity expansion model does not estimate value of deferred transmission and distribution, therefore EE levelized cost input into model should be “net” of deferred T&D.
  - Example – If non-energy benefits, such as the value of water savings, are to be included in the valuation of energy efficiency, the levelized cost input into the model should be “net” of the value of such benefits

Special Considerations for Direct Competition Method Modeling "Acquisition Logic"

- Acquisition Logic:
  - Capacity expansion models require decision rules that determine when a resource is acquired
  - Unlike supply side resources EE and DR can be acquired across a wide range of costs (i.e., it has a nearly continuous supply curve)
  - EE and DR supply curves can be represented as "continuous" or as "discrete cost bin"
    - If "price bins" are used, care should be taken to avoid the "binning game"
  - A capacity expansion model must be able to compare the cost and load impacts of EE and DR with the cost and load following capability of supply side generation to determine which resource meets forecast needs for energy and capacity at the lowest cost

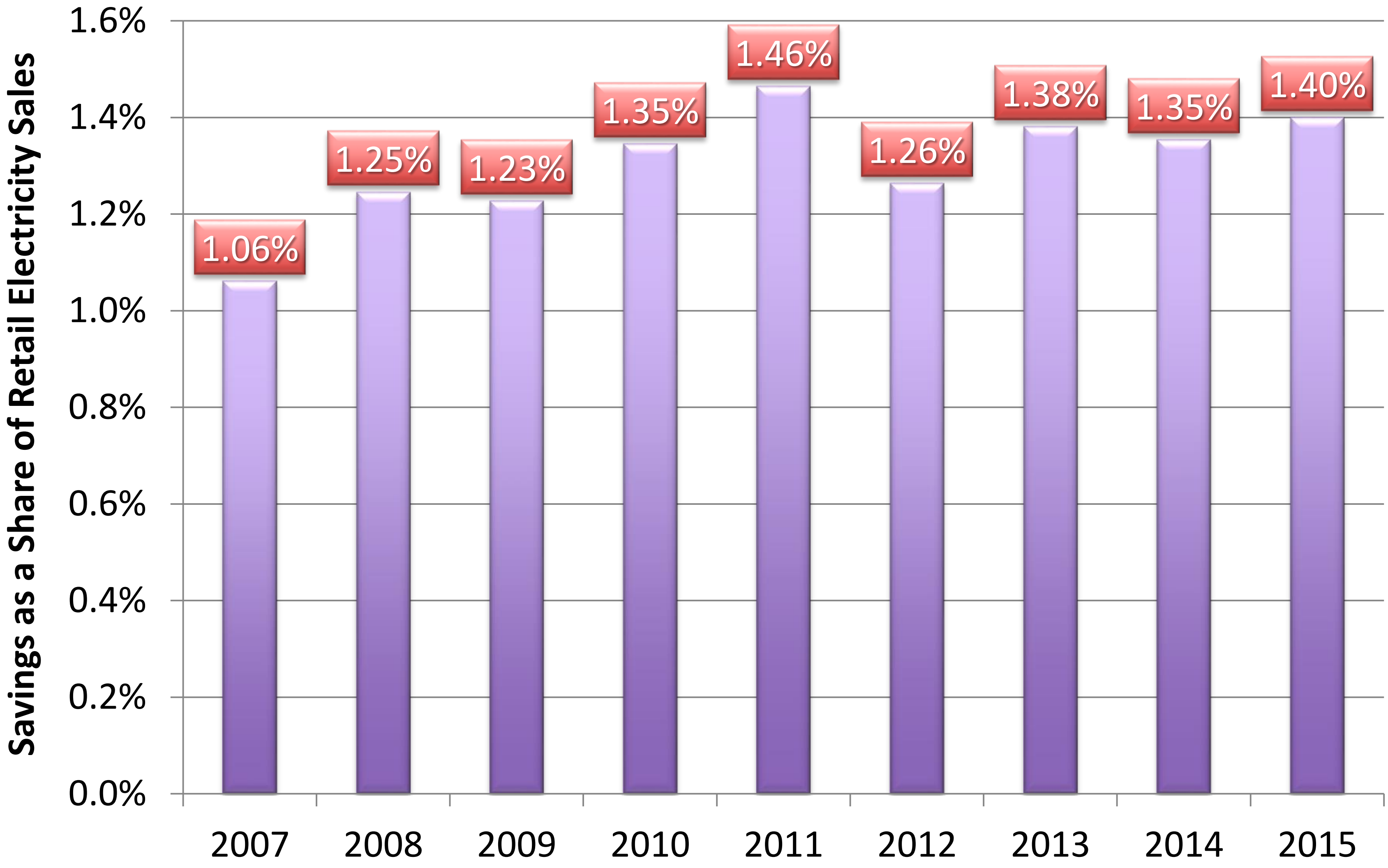
Special Considerations for Direct Competition Method Input Assumptions Regarding Pace of Acquisition

- Maximum Retrofit Pace Constraint:
  - Resource optimization models will "build" (i.e., replace all existing lamps in a single year) all retrofit EE and DR resources with cost below the marginal dispatch of existing generating resources at first opportunity – unless constrained
  - Real-world infrastructure limits maximum annual retrofit development Constraints on the annual acquisition of retrofit EE and DR resources must be set in the model. Limits may be fixed or grow through time fixed for 20-yrs, i.e., assumes infrastructure never grows)
- Acquisition Logic:
  - Modeling supply curve, whether continuous or in cost "bins" can result in acquisition lowest to highest cost measures through time
  - Real world programs don't acquire <u>only</u> the lowest cost measures first
  - Acquisitions must be modeled so EE resources are selected across entire supply curve since program costs meld low and higher cost measures

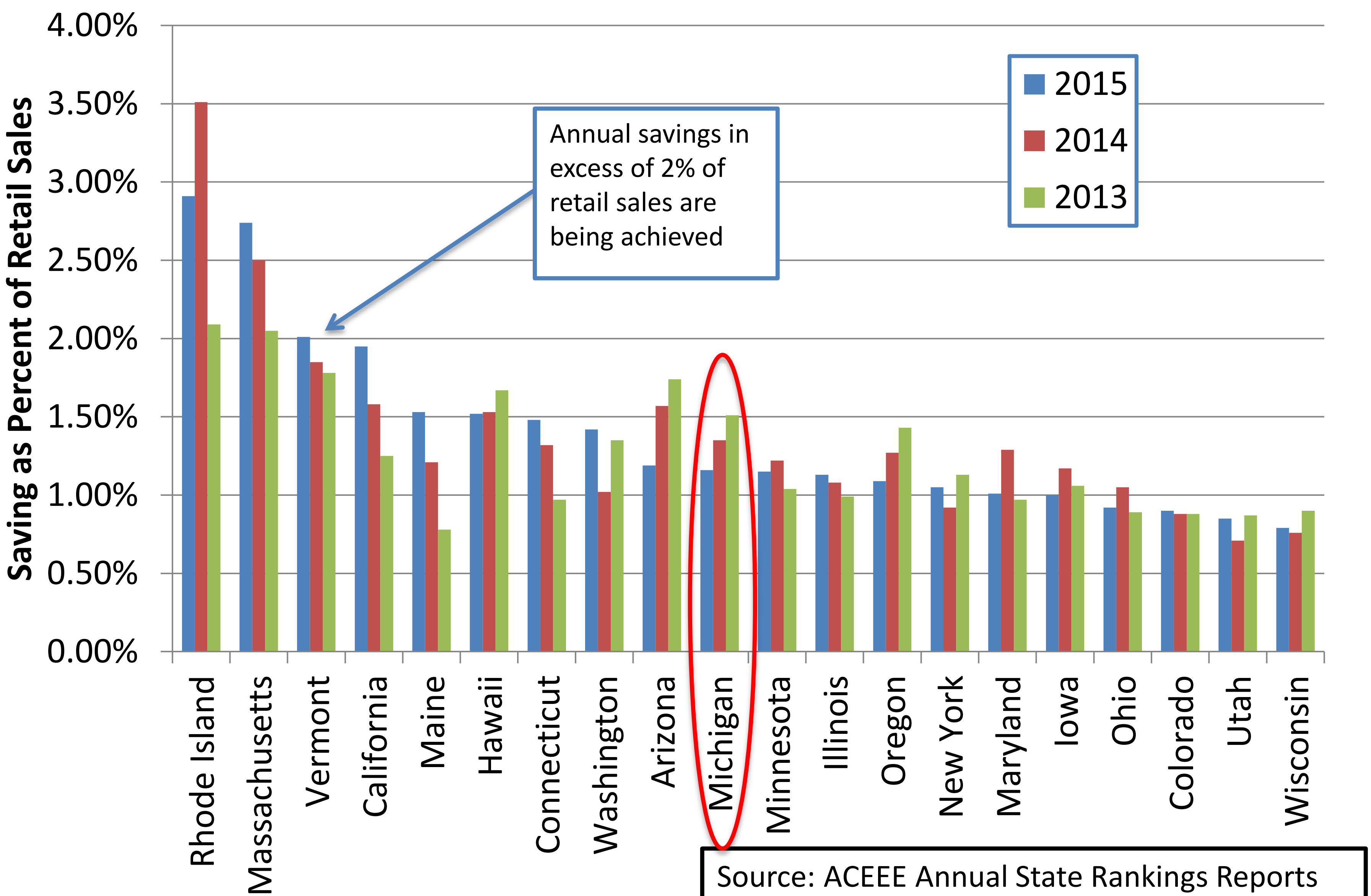
What Evidence Do We Have?

- Annual Achievements by Utility Programs in Northwest and Other States
- Short-Term Achievements in the Hood River Conservation Project
- Long-Term (20 year) Achievements Relative to Council's Northwest Power Plan expectations

Sustained Annual Savings of Over 1% of Retail Savings Have Been Achieved for Nearly A Decade Across Four Northwest States



Annual Achieved Electricity Savings by Top 20 States
Multiple States (Including MI) Have Exceeded 1.5% of Retail Sales

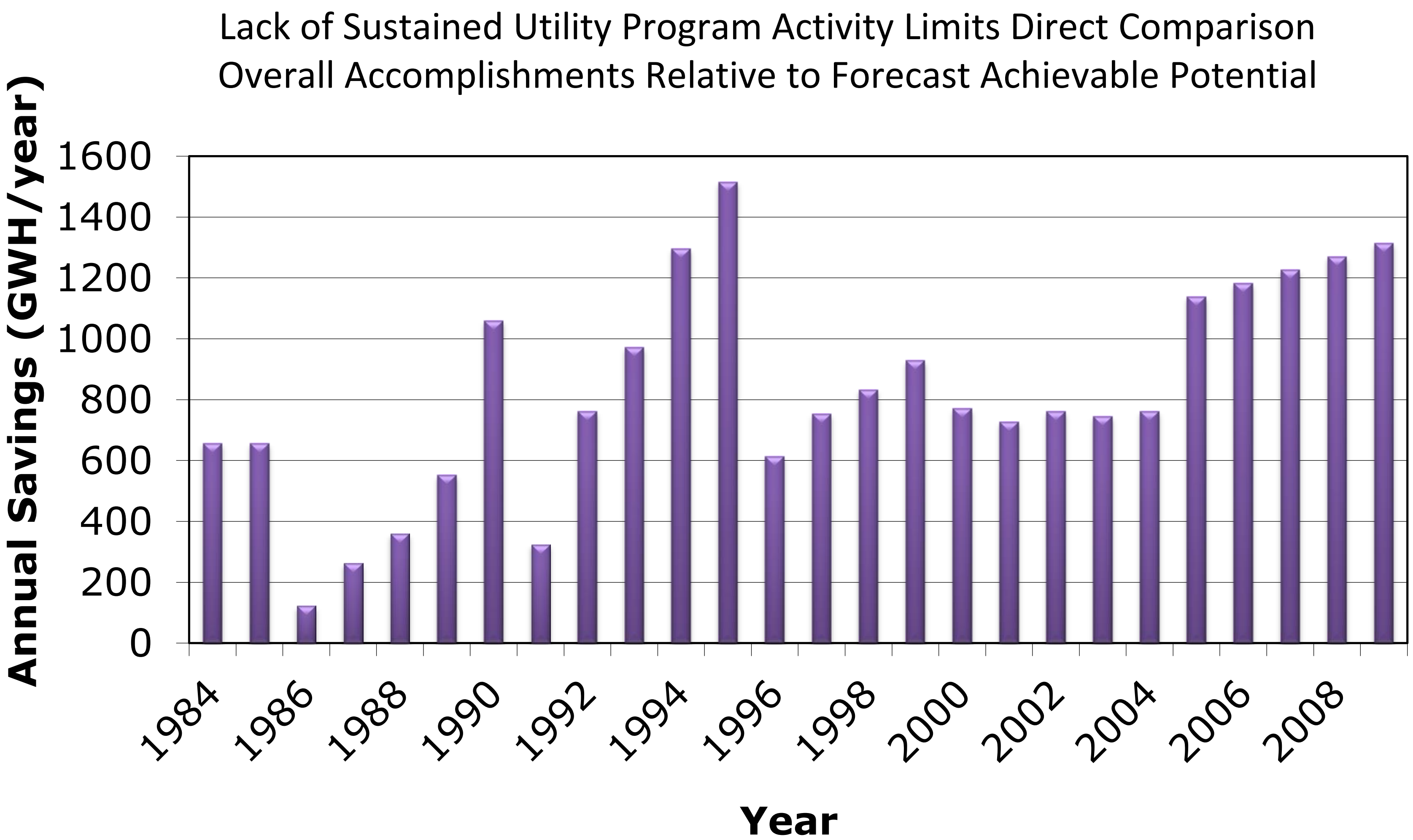


Evidence: Hood River

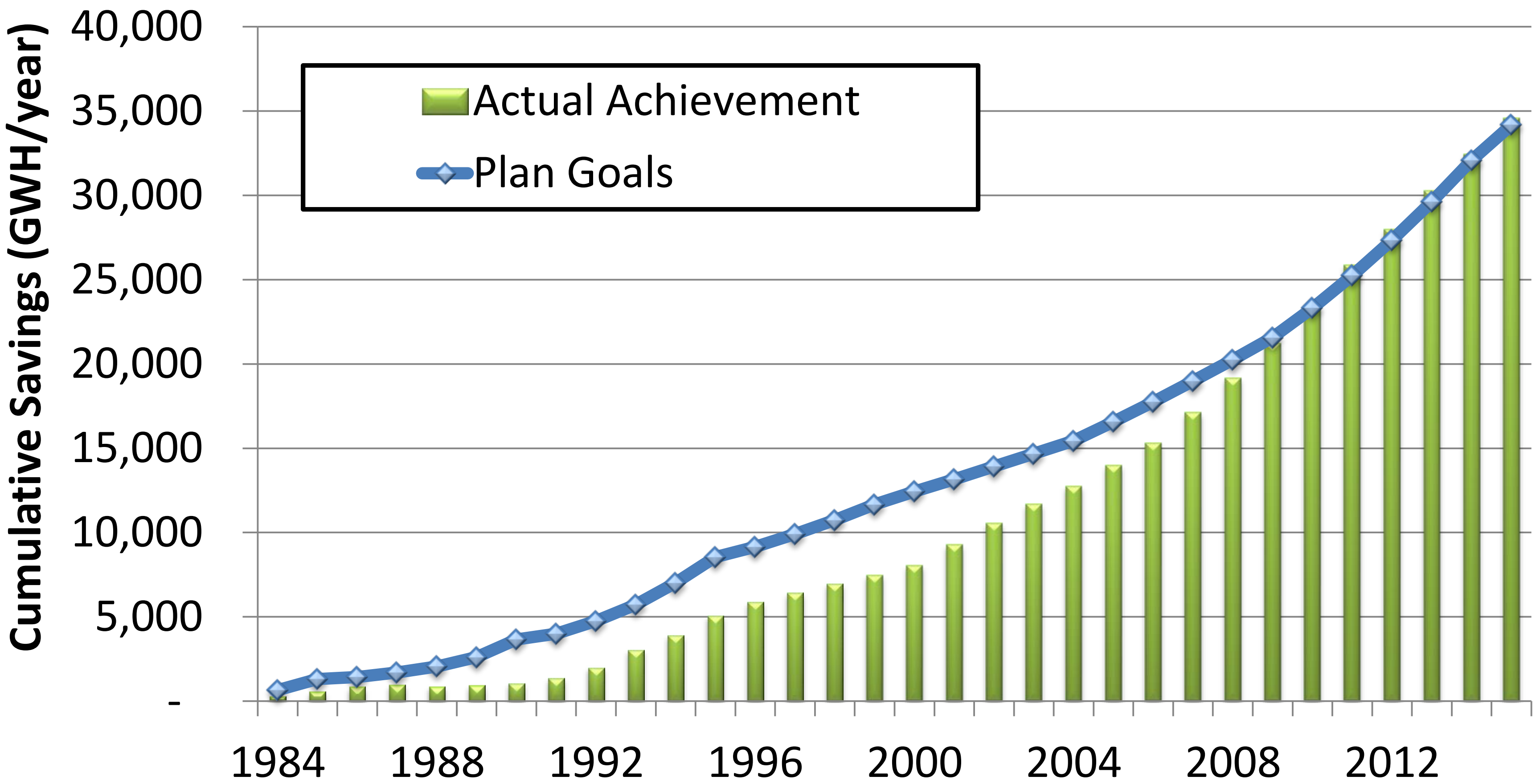
- Hood River Conservation Project
- 1982-84 experiment in Hood River County Oregon
- Goal – "Super" Weatherize all electric-heated homes in the county over a period of two years*
- Measures installed at no cost to participants
- Result: Over 85% of Technically Feasible Residential Weatherization Measures Installed Within Two Year Period

*Recommended measure set included R49 Attics, R38 Underfloor, R11 Wall Insulation and Double Pane Storm Windows.

Long Term Achievable Potential
Evidence: Aggregate Forecast vs. Actual Achievements Over 20 Years



Despite the Lack of Sustained Utility Program Activity, Actual Accomplishments Have Met Achievable Potential Expectations



*Achievements reflect utility and NEEA savings only. Savings from codes and standards are included as baseline adjustments in each plan's baseline load forecast

Long Term Achievable Potential

Sample Evidence: Disaggregated Forecast vs. Actual Achievements Over 20 Years

- New Residential and Commercial Construction
- Residential Appliances
- Residential Water Heating
- Commercial Lighting
- Commercial HVAC Equipment

Evidence: Residential New Construction

1983 Goal: 40% Improvement in Space Heating Use of which 85% Is Achievable by 2002

Vintage	Annual Use (kWh/sq../yr.)	Percent of 1983 Use	Improvement over 1983
1983	6.3	100%	0%
1986	5.5	88%	12%
1989	5.4	86%	14%
1992	4.0	64%	36%
2001	3.7	59%	41%

Evidence: Commercial Lighting Power Density Codes Exceed Efficiency Requirements

Building Type	Lighting Power Density (Watts/sq.st.)				
	1983 Plan Target	Oregon 2004	Washington 2004	Idaho and Montana	Seattle 2004
Office	1.5	1.0	1.0	1.0	1.0
Retail Stores	1.5	Varies 1.5+	Varies 1.5+	Varies 1.5+	Varies 1.5+
Schools	2.0	1.1	1.35	1.2	1.2
Warehouses	0.7	0.5	0.8	0.8	0.5

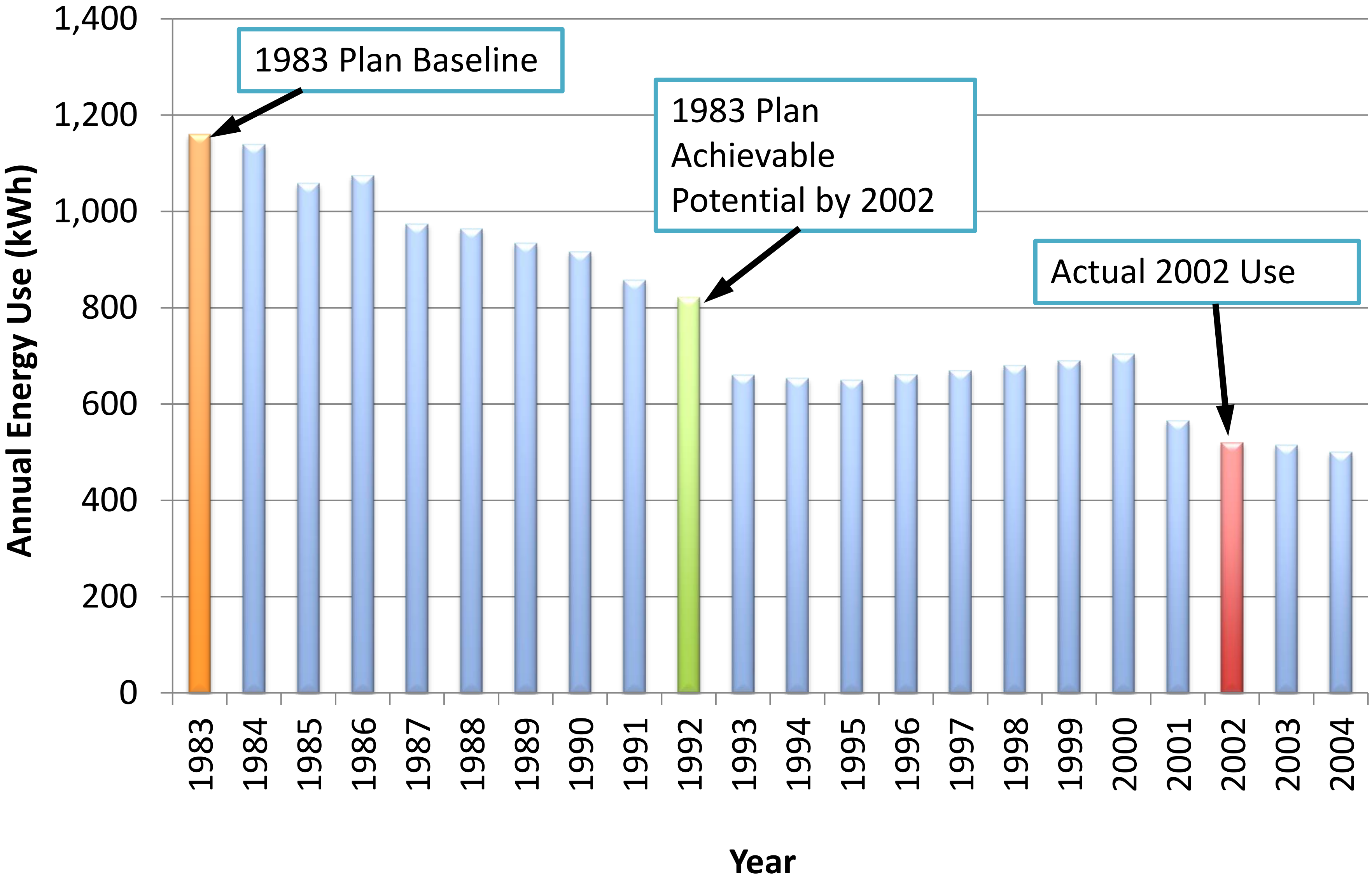
Evidence : Lighting Power Density in Existing Commercial Buildings

Audit Date	Lighting Power Density (Watts/sq..)			Reduction in Lighting Power Density (%)		
	All Buildings	Offices	Retail	All Buildings	Office	Retail
As found in 1987	1.5	1.6	1.9			
As found in 2001	1.2	1.4	1.5	20%	13%	21%

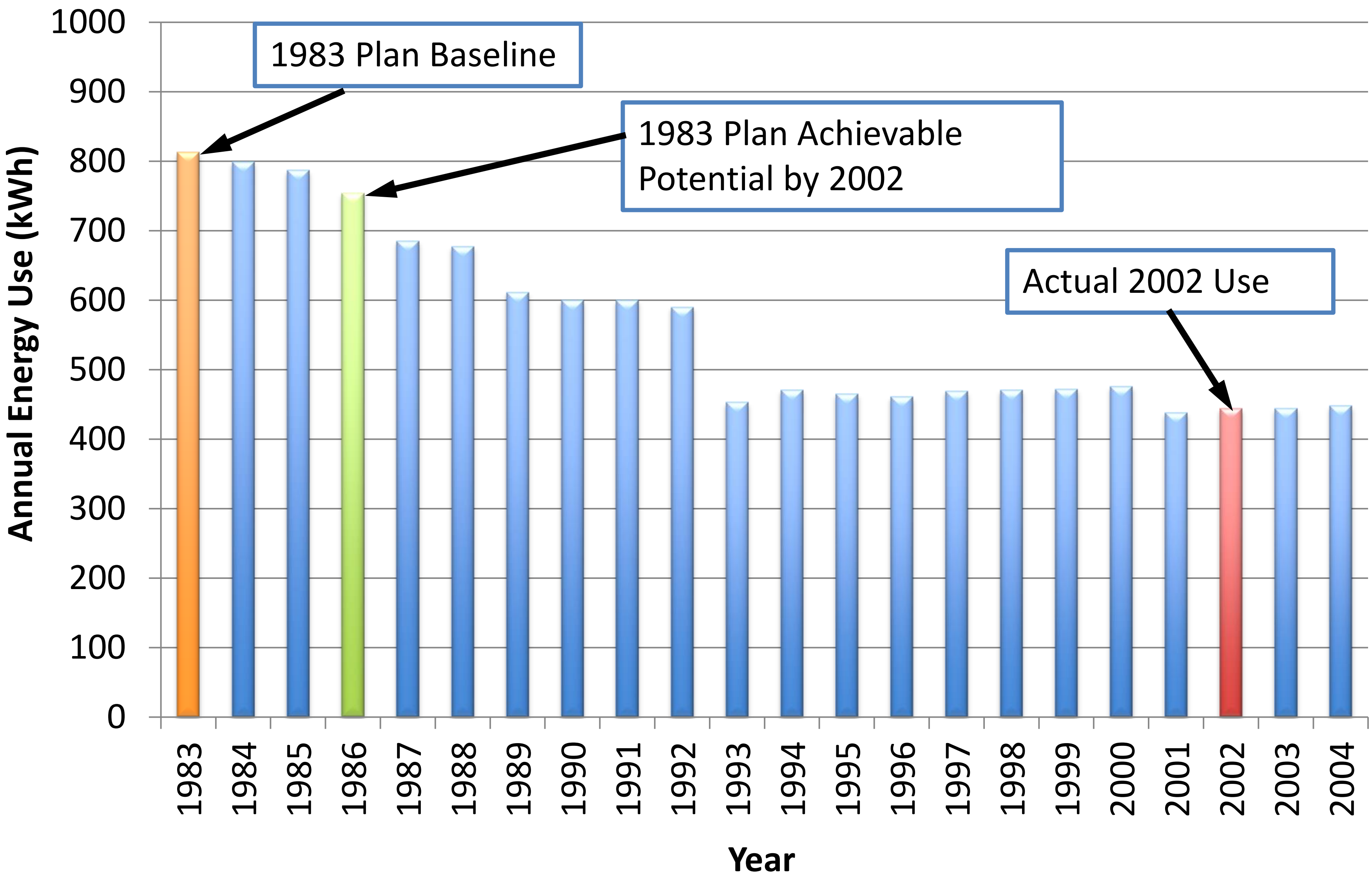
Evidence: Commercial HVAC Equipment Efficiency Requirements

System Type	Capacity Under 65,000 Btu/hr		Capacity 65,000 Btu/hr and Larger	
	1983 Achievable SEER	2002 Code Minimum SEER	1983 Achievable EER	2002 Code Minimum EER
Air Cooled	7.8	13	8.2	11.0
Evaporative or Water cooled	8.8	14	9.2	14.0

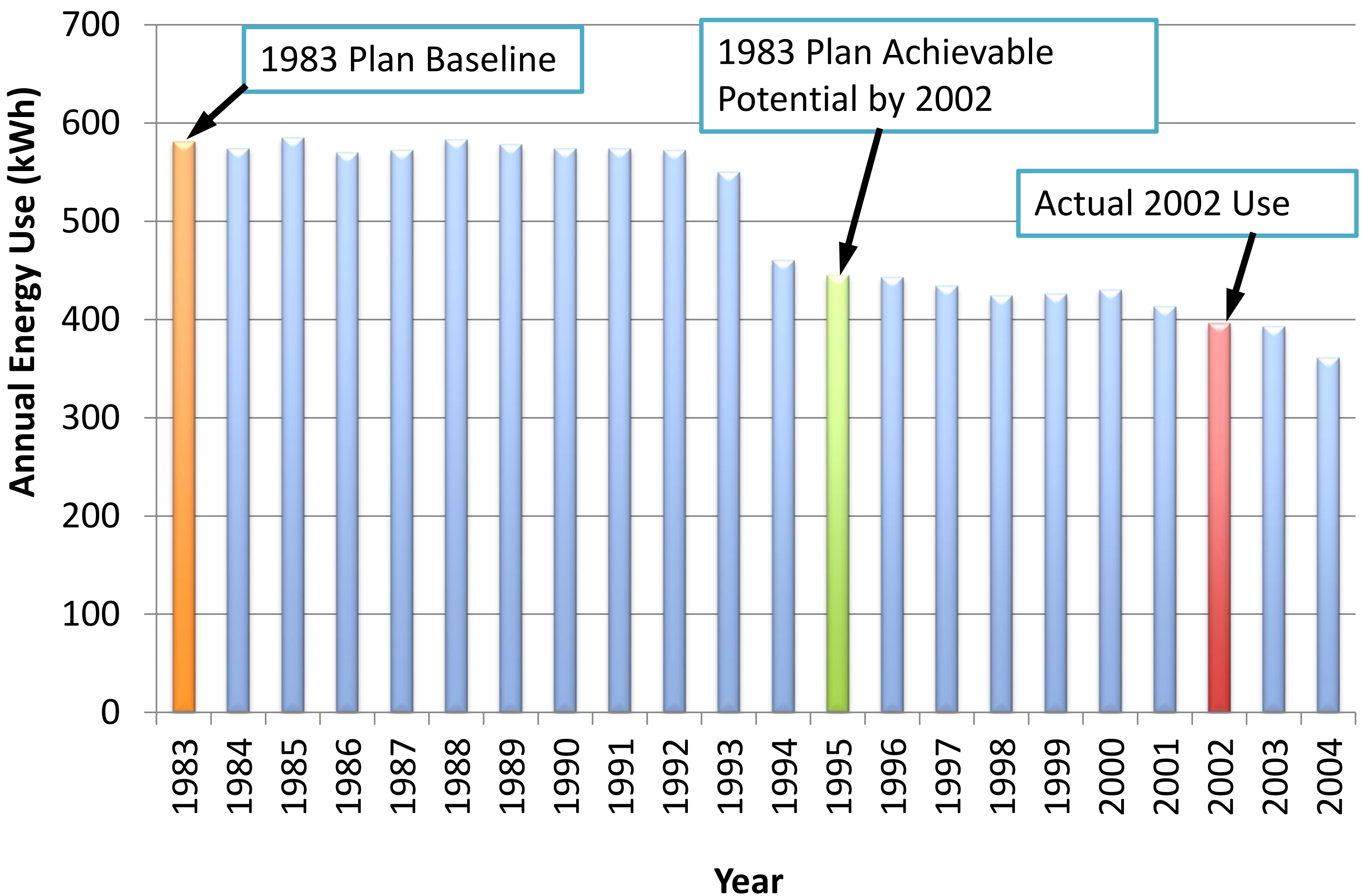
Evidence: Residential Appliances – New Refrigerators



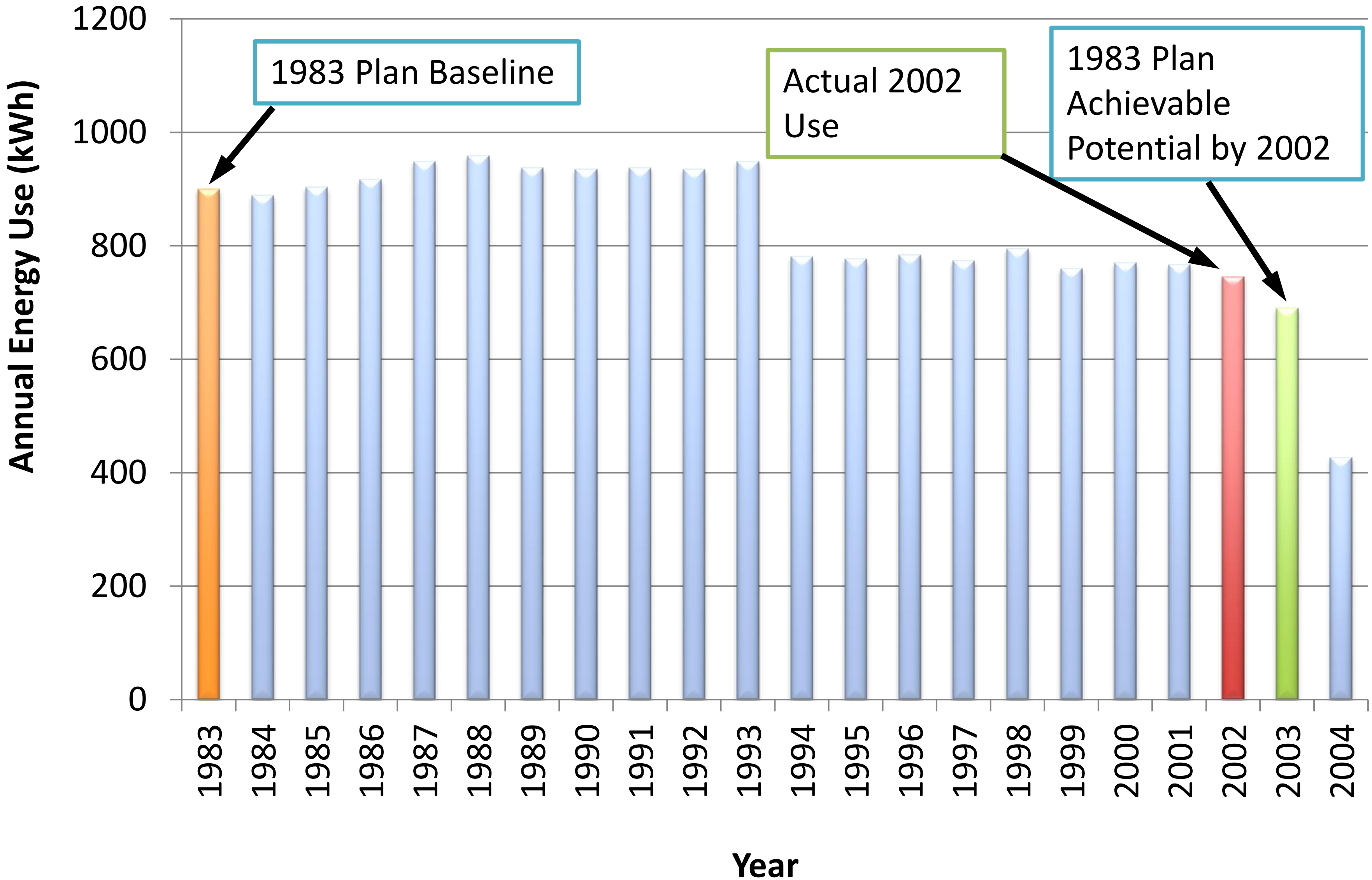
Evidence: Residential Appliances – New Freezers



Evidence: Residential Appliances – New Dishwashers



Evidence: Residential Appliances – New Clothes Washers



Evidence: Residential Water Heating Use